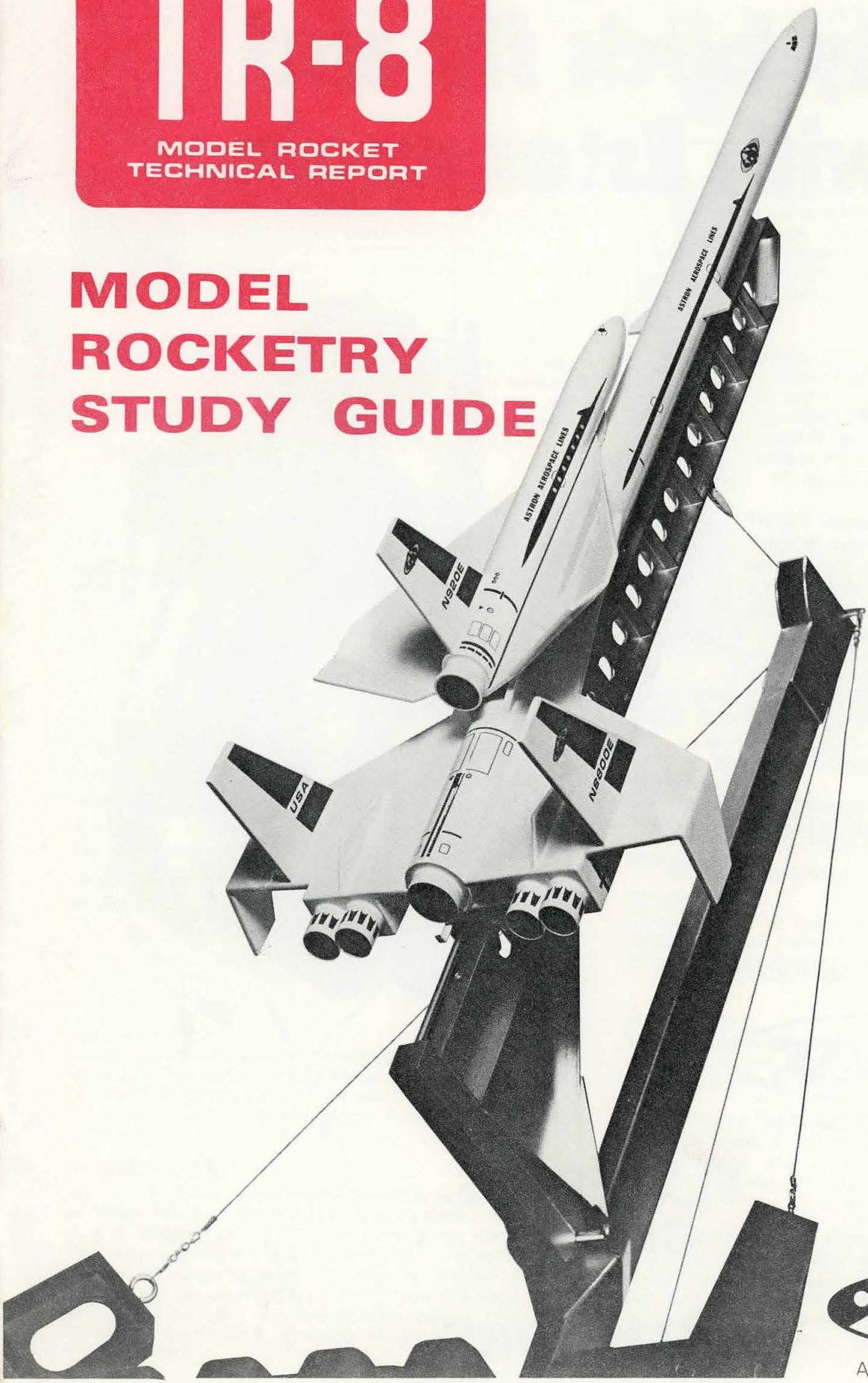
TR-8

MODEL ROCKET
TECHNICAL REPORT

MODEL ROCKETRY STUDY GUIDE



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A SUBSIDIARY OF DAMON

1972 National Champion Jon Randolph says

"My birds fly and win with Estes engines"

Jon Randolph is a competitor. And a winner.

He designs his own rockets. Chooses carefully from the best components he can find. That's why his birds fly with Estes engines.

Using Estes power, Randolph's 1971 credentials include three area D Division meet wins, two D regional meet wins, and of course the U.S. National D Division Championship at NARAM-13.

He also racked up first places in scale and space systems at NARAM-12 and firsts in scale and Pee Wee Payload at NARAM-13 when his Estes Mini-Brute rocket — powered by an Estes engine, of course — soared a stunning 240 meters.

Of course we're pleased and proud that Jon Randolph uses our engines. But we're not surprised.

Try them in your bird, and you'll understand why.

Choice of the serious rocketeer

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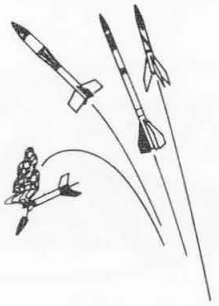

FLY ESTES CHOICE OF CHAMPIONS

ARMED AND COUNTING

Becoming an Expert model rocketeer requires basic knowledge, skills, and experience acquired through a planned program of study and activity. By following this guide step by step and completing the tests at the end of each section, you will obtain much self-satisfaction in accomplishment and obtain great benefit and enjoyment from the exciting world of solid propellant model rocketry.

When you have completed all sections of the Model Rocketry Study Guide take the Expert Rocketeer Final Exam at the end of this booklet. Return your exam answer sheet to us for checking, and we will send you an official Expert Rocketeer Award Certificate. Be sure to keep an accurate record of your model rocket activities with the "Project/Flight Record" provided.

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CONTENTS

SECTION I Basic Model Rocketry 1

GLOSSARY Basic Terms 5

SECTION TEST 10

SECTION II Advanced Model Rocketry 13

GLOSSARY Advanced Terms 20

SECTION TEST 26

SECTION III Boost Gliders 29

GLOSSARY Glider Terms 31

SECTION TEST 36

FINAL EXAM 39

PROJECT / FLIGHT RECORD 42

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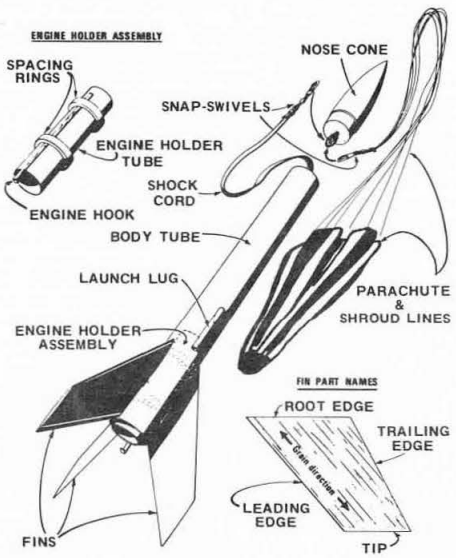
SECTION I

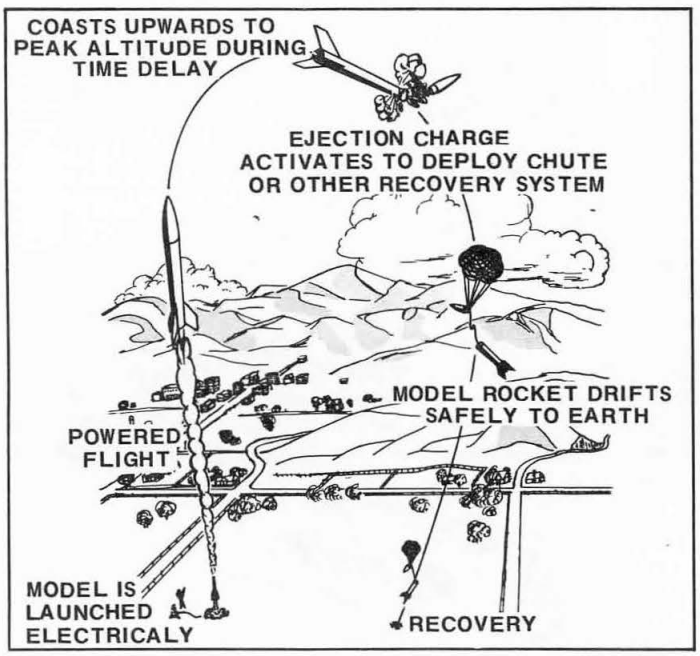
BASIC MODEL ROCKETRY

T-10 Read the "Model Rocketry Technical Manual". This brief but detailed manual on model rocketry is a fine beginner's guide. Later it serves as a handy reference as you advance in model rocketry. Understanding of the basic information that is offered in the manual is a must if you hope to become an Expert in your model rocket activities.

T-9 Learn the basic parts of a model rocket.



Study the flight phases of a model rocket.


COASTS UPWARDS TO PEAK ALTITUDE DURING TIME DELAY
EJECTION CHARGE ACTIVATES TO DEPLOY CHUTE OR OTHER RECOVERY SYSTEM
MODEL ROCKET DRIFTS SAFELY TO EARTH
POWERED FLIGHT
MODEL IS LAUNCHED ELECTRICALY
RECOVERY

T-8 Obtain the basic modeling tools and materials. These should include at least the following:

a. **Modeling knife or single edge razor blade**
b. **Metal-edged ruler**
c. **Sandpaper (fine or extra fine)**
d. **Scissors**
e. **Estes white glue**
f. **Pencil or ball point pen**
g. **Cardboard or cutting board**
h. **Sanding sealer**
i. **Paint brush**
j. **Paint (either butyrate dope or spray enamel)**
k. **Paint thinner**

T-7 Learn the basic modeling techniques. If your model rocket is to perform in the manner for which it was designed, care is necessary in assembly. The skill needed for proper construction can be acquired only by practicing with the tools and materials listed above. If you are not already an experienced modeler we suggest that you practice the following techniques as illustrated in the "Model Rocketry Technical Manual."

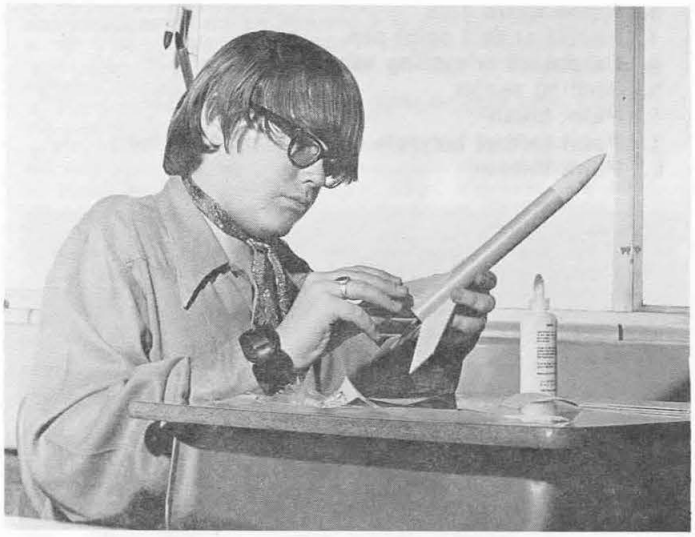
a. Measure distances on scrap balsa with a ruler, then mark and draw lines for cutting. With a modeling knife or razor blade, cut the balsa along the marked lines. This exercise is extremely important since it will help you learn to cut your fins accurately. Do not forget that the grain of the balsa should always run the same direction as the leading edge of the fin.

b. With scrap balsa practice sanding the surfaces and edges to the correct shape with a smooth finish. Remember that the root edges of the fins must be sanded "square" to insure a perfect fit to the body. The leading and trailing edges must be rounded to

insure greater aerodynamic efficiency. A smooth finish reduces drag to a minimum and permits maximum performance.

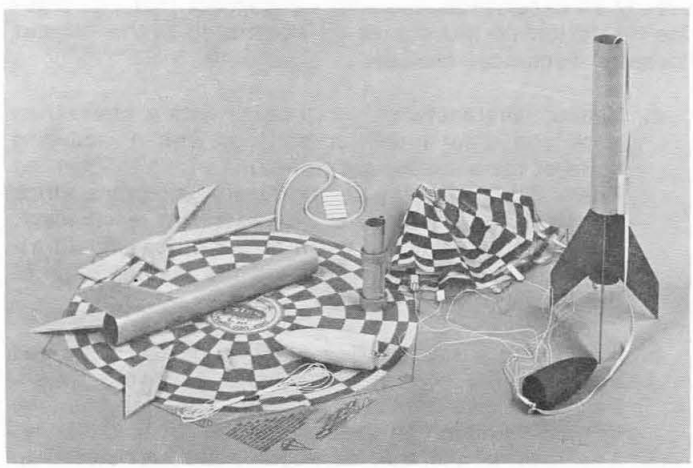
c. Learn glue application techniques by gluing pieces of cardboard and balsa together. Experience will teach you the proper amount of glue required, drying time, etc. Joints should always be reinforced by applying a smooth "fillet" of glue. This adds to the appearance of your rocket as well as increasing aerodynamic efficiency.

d. Practice sealing and painting techniques to achieve a fine finish. Cover all balsa parts with two or three brushed coats of sanding sealer. Be sure to let dry and sand all areas lightly with fine sandpaper between coats. Base color and second colors, either sprayed or brushed, should always be applied in thin coats. Remember that the performance of your rocket as well as its appearance will be affected by the finish.



T-6 For your first rocket build the Astron Alpha or the Astron Alpha III, a single-stage model rocket by Estes with parachute recovery. The Astron Alpha is an excellent model for both beginners and experienced rocketeers. Building and launching this rocket will teach you the basic principles of model rocket technology and provide you with a background for advancement to multi-stage, cluster, boost-glider, and scale model rockets.

Read the instructions through carefully before starting construction. To prevent a mistake, be sure to follow the instruction sheet step by step. Don't learn the hard way!



Examine the parts packed in the kit with Parts List given in the instruction sheet.

Now, construct and finish your model using the proper tools, knowledge, and skills gained from practice.

T-5 Learn the Model Rocketry Safety Code. Be an Expert and keep your model rocket activities safe and and enjoyable by following the Safety Code at all times.

MODEL ROCKET SAFETY CODE

1. **Construction** – My model rockets will be made of lightweight materials such as paper, wood, plastic. and rubber, without any metal as structural parts.
2. **Engines** – I will use only pre-loaded factory-made model rocket engines in the manner recommended by the manufacturer. I will not change in any way nor attempt to reload these engines.
3. **Recovery** – I will always use a recovery system in my model rockets that will return them safely to the ground so that they may be flown again.
4. **Weight Limits** – My model rocket will weigh no more than 453 grams (16 ozs.) at liftoff, and the engines will contain no more than 113 grams (4 ozs.) of propellant.
5. **Stability** – I will check the stability of my model rockets before their first flight, except when launching models of already proven stability.
6. **Launching System** – The system I use to launch my model rockets must be remotely controlled and electrically operated, and will contain a switch thai will return to "off" when released. I will remain at least 10 feet away from any rocket that is being launched.
7. **Launch Safety** – I will not let anyone approach a model rocket on a launcher until I have made sure that either the safety interlock key has been removed or the battery has been disconnected from my launcher.
8. **Flying Conditions** – I will not launch my model rocket in high winds, near buildings, power lines, tall trees, low flying aircraft, or under any conditions which might be dangerous to people or property.
9. **Launch Area** – My model rockets will always be launched from a cleared area, free of any easy to burn materials, and I will only use non-flammable recovery wadding in my rockets.
10. **Jet Deflector** – My launcher will have a jet deflector device to prevent the engine exhaust from hitting the ground directly.
11. **Launch Rod** – To prevent accidental eye injury I will always place the launcher so the end of the rod is above eye level or cap the end of the rod with my hand when approaching it. I will never place my head or body over the launching rod. When my launcher is not in use I will always store it so that the launch rod is **not** in an upright position.
12. **Power Lines** – I will never attempt to recover my rocket from a power line or other dangerous places.
13. **Launch Targets & Angle** – I will not launch rockets so their flight path will carry them against targets on the ground and will never use an explosive warhead nor a payload that is intended to be flammable. My launching device will always be pointed within 30 degrees of vertical.
14. **Pre-Launch Test** – When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through pre-launch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching.

Revised 2/4/70

This Solid Propellant Model Rocketry Safety Code is approved by the National Association of Rocketry and the Hobby Industry Association of America.

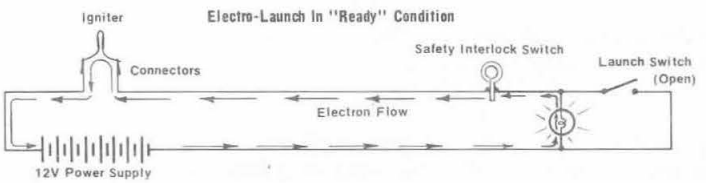
T-4 Study the performance of model rocket engines. Learn the various parts of a model rocket engine and why different engines are recommended for specific missions. Rocket engine design, classification, operation, and performance are explained in the "Model Rocket Technical Manual".

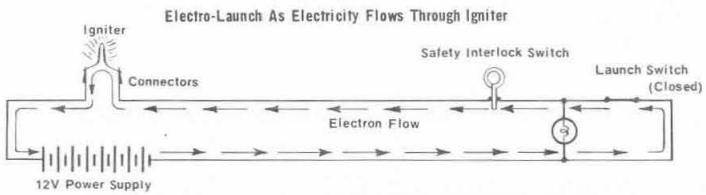
Do not make engine substitutions contrary to catalog and instruction recommendations.

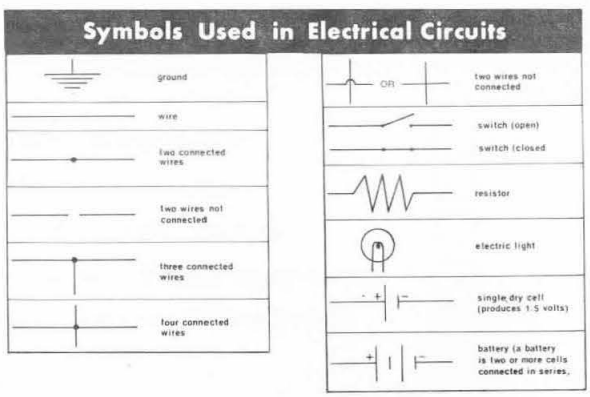
A review of Newton's Third Law of Motion ("For every action there is an equal but opposite reaction.") will help you in gaining a better understanding of model rocket operation. For more information on Newton's laws of motion refer to Model Rocket News, Volumes 8 & 9.

T-3 Build an electrical ignition system for launching your model rockets. The Estes Launch Control System with plastic Porta-Pad launcher is an excellent combination. Remember the Safety Code states that the only safe way to launch model rockets is by electrical means.

Refer to the "Model Rocketry Technical Manual" for a basic understanding of model rocket launch systems. A review of basic electricity, electrical circuits, Ohm's Law, etc., will allow you to gain additional understanding of launch systems and engine ignition.

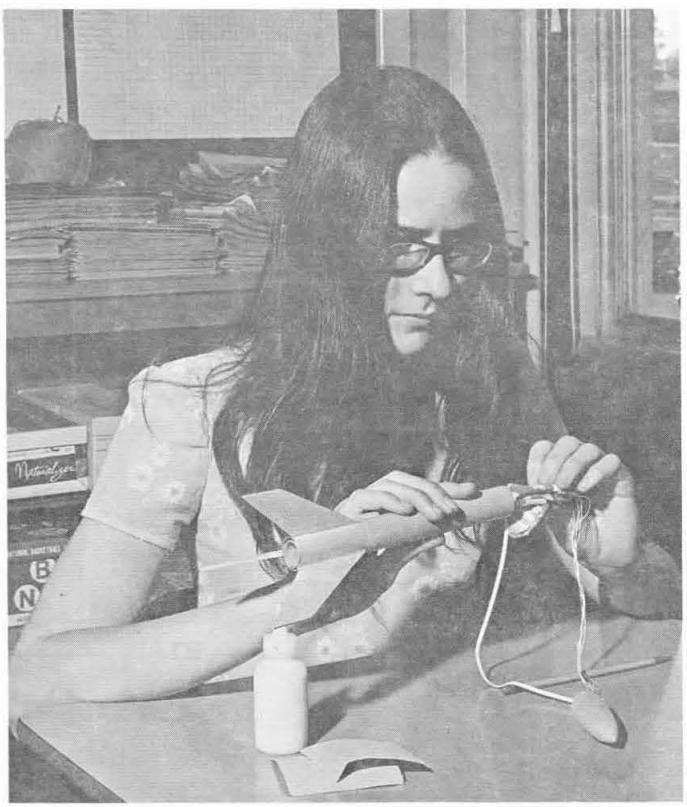






More comprehensive information concerning launch systems is featured in the Estes publication, "Model Rocket Launch Systems". This booklet is especially valuable if you are building your own launch system.

T-2 Carefully prepare your model rocket for launching. Follow the instructions outlined in the "Model Rocketry Technical Manual" and on the instruction sheet provided in your kit. Remember, don't neglect the details of proper preparation.



T-1 "Blast-off". Launch your rocket!

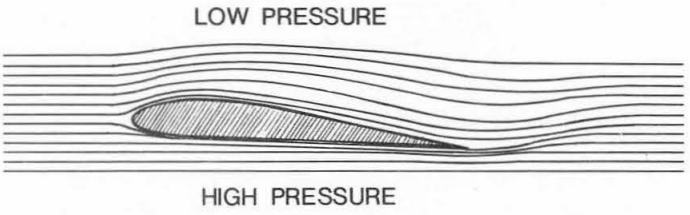
Be sure to carry out a pre-flight safety check of the launch area and a short count down before lift-off. By following this guide-step by step, your first flight will be a successful one. Be sure to record your first launch in your Project/Flight Record.

NOTES

GLOSSARY

BASIC TERMS

Airfoil:
A cross-section of a body designed to produce a lifting force perpendicular to its surface when there is a relative motion between it and the surrounding air.



Amateur Rocketry:
Professionally supervised rocketry activities carried out by knowledgeable amateurs.

Ampere (amp):
The unit used in measuring the strength of an electrical current; an ampere is equal to the steady current produced by one volt applied across the resistance of one ohm.

Apogee:
The point in the orbit of a satellite where it is farthest from Earth.

Armed:
Term used to signify the moment an ignition system is activated to check continuity allowing the countdown to begin.

Average Thrust:
The total impulse of a rocket engine divided by the time duration of its thrust; the thrust that an engine would have if its thrust were constant from ignition to burnout.

Balsa Wood:
A very light, strong wood grown in Ecuador and used in the structure of model airplanes and model rockets.

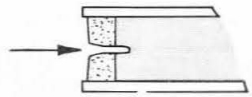
Basement Bomber:
Person with inadequate knowledge who attempts to mix his own propellant and usually builds his rockets out of metal.

Blast Deflector:
Metal plate which protects launcher base and ground from rocket's exhaust.

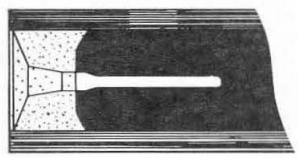
Body Tube:
Light cardboard cylinder which is the main frame for the rocket.

Burnout:
The point at which a rocket engine ceases to produce thrust; generally, the point at which all propellant has been burned.

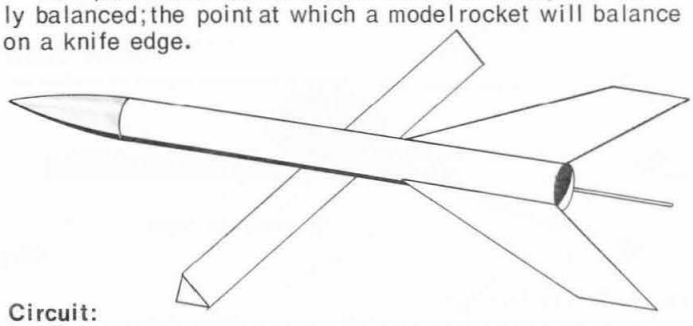
Centerbore:
Round cavity in propellant grain for easy ignition and controlled burn.



Center (core) burning:
Model rocket engine with deep centerbore providing a large propellant burning area resulting in a high thrust level. Used in Series II engines.



Center of Gravity:
The point in a rocket around which its weight is evenly balanced; the point at which a model rocket will balance on a knife edge.



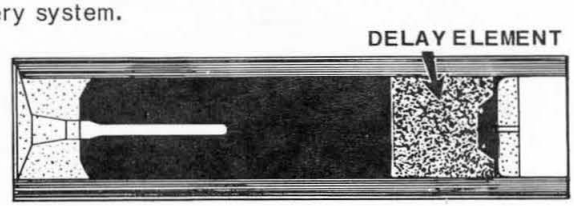
Circuit:
The complete path of an electric current including the source of electric energy.

Coast Period:
Mid-flight phase between burnout and activation of ejection charge during which a delay element emits a smoke trail.

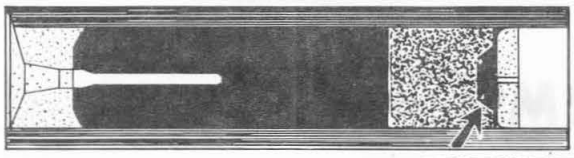
Countdown:
Practice of verbally counting down to launch a rocket. Example: "5...4...3...2...1...Ignition,"

Current:
The movement of electricity or rate of electrical flow; measured in amperes.

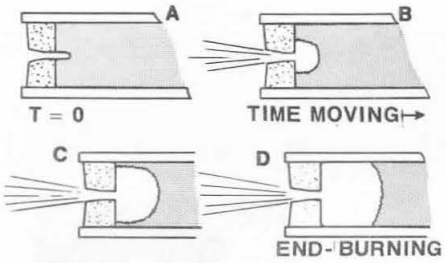
Delay Element:
A slow-burning chemical loaded into a model rocket engine during manufacture to provide a time delay and a smoke trail between burnout and the activation of the recovery system.



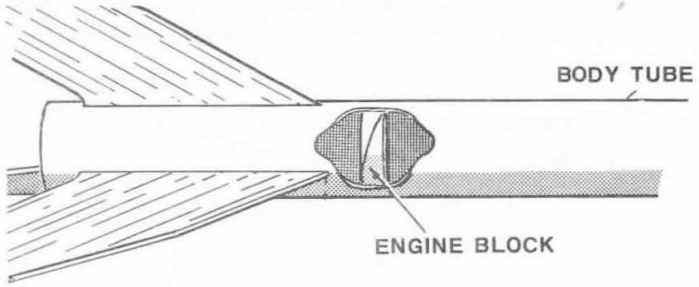
Ejection Charge:
Charge contained in single and upper stage engines which deploys the recovery device.



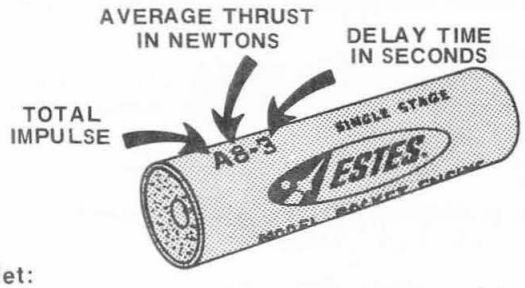
End-Burning:
Solid propellant rocket engine which is ignited at the nozzle end and burns through to the forward end; model rocket engine with slight centerbore producing a high initial thrust dropping off to a sustaining level.



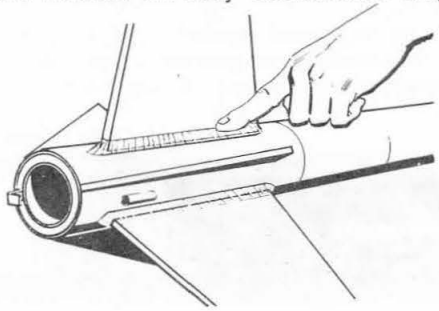
Engine Block (Mount):
A hollow block or ring positioned in a model rocket body to prevent the engine from moving forward during acceleration while allowing a free forward travel of the ejection gases.



Engine Classification:
Code designation, stamped on engines, giving data on an engine's performance capabilities.



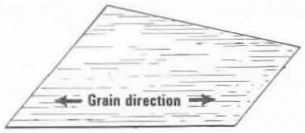
Fillet:
To place glue or other reinforcing material at the joint of the fin and the body tube. It provides greater strength at a point where maximum stress will be applied during flight and reduces fin-body interference drag.



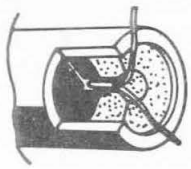
Fin:
The stabilizing and guiding unit of a model rocket (which should be in a symmetrical form of three, four, or possibly more and made of reinforced paper, balsa, or plastic); an aerodynamic surface projecting from the rocket body for the purpose of giving the rocket directional stability.

Finishing:
The art of producing a quality surface on the model rocket. A well-finished rocket with a smooth surface and properly filleted fins with adequate airfoil will allow a model to perform better than a model not so finished.

Grain, Balsa:
The grain of any wood is the direction in which the fibers run.



Igniter:
An electrical device which initiates the combustion process in a rocket engine.

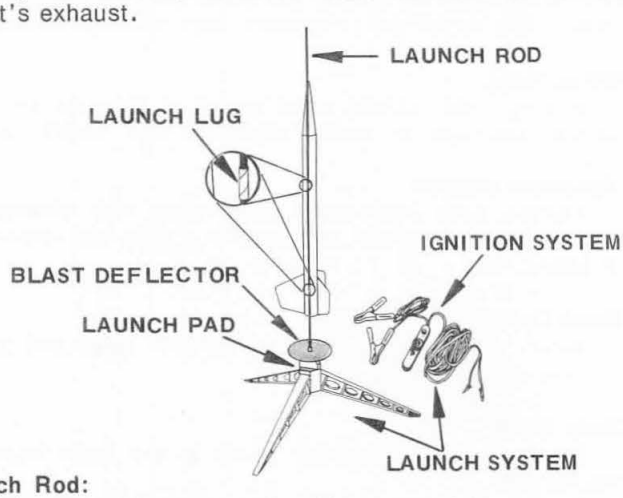


Ignition:
The instant at which a model rocket engine's propellant begins to burn.

Ignition System:
Electrical system used to ignite a model rocket engine.
(See drawing of launch pad.)

Launch Lug:
Round, hollow tube which slips over the launch rod to guide the model during the first few feet of flight until stabilizing velocity is reached.
(See drawing of launch pad.)

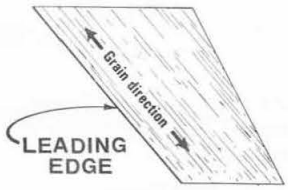
Launch Pad:
Structure used to support and guide a model in a vertical path during the first few feet of flight until stabilizing velocity is reached; includes blast deflector to deflect rocket's exhaust.



Launch Rod:
Rod used to support and guide a model in a vertical path during the first few feet of flight until stabilizing velocity is reached.
(See drawing of launch pad.)

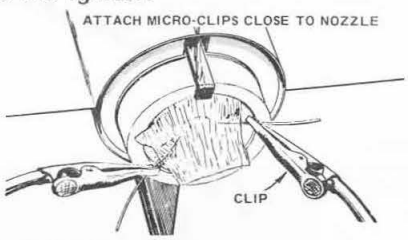
Launch System:
Combination of ignition system and launch pad. (See drawing of launch pad.)

Leading Edge:
The very front surface of a fin or a boost-glider wing that is exposed to the greatest amount of air pressure build-up. The grain of the balsa wood should run parallel to the leading edge to allow for maximum strength.

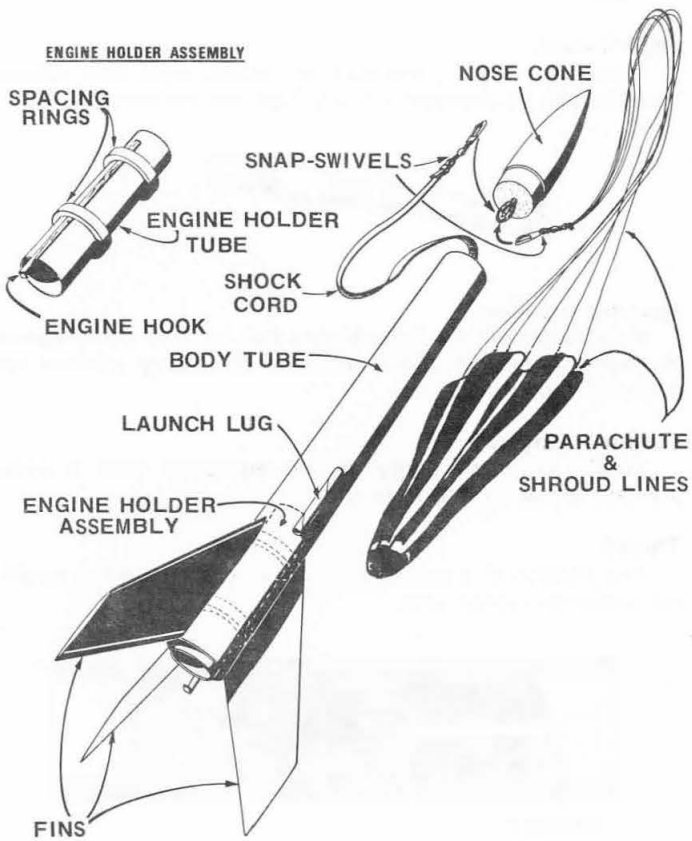


Lift-Off:
First motion of a rocket after ignition.

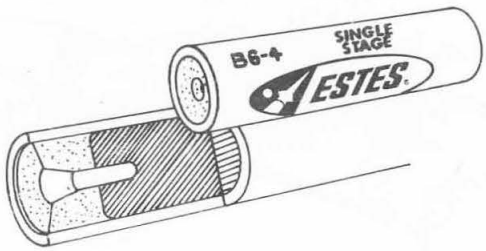
Micro-clip:
Tiny, flat-jawed alligator clip used to attach the ignition system to the igniter.



Model Rocket, Solid Propellant:
A rocket made of light materials such as paper, wood, plastic, or rubber without the use of substantial metal parts, powered by a commercially manufactured solid propellant model rocket engine; rising without the necessity of lift-producing aerodynamic surfaces; and containing a recovery device to lower it safely back to the ground.



Model Rocket Engine, Solid Propellant:
A commercially manufactured, solid propellant rocket engine in which all chemical ingredients of a combustible nature are pre-loaded and ready for use.



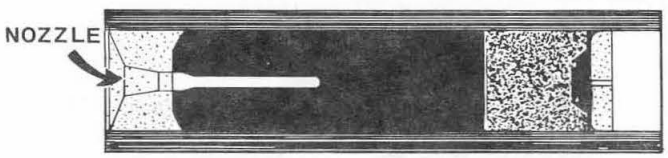
Newton:
The amount of force needed to move a mass of one kilogram with an acceleration (change in velocity) of one meter per second each second; one Newton is equal to 0.225 pounds of force.

Newton-Second:
Metric measurement for a rocket's total impulse.

Newton's Third Law:
"For every action there is an equal but opposite reaction."

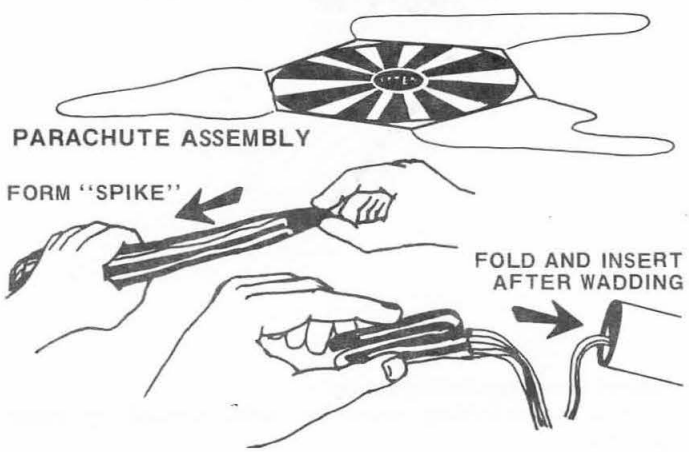
Nose Cone:
The foremost surface of a model rocket, generally tapered in shape to allow for streamlining, usually made of balsa or plastic.

Nozzle:
The exhaust duct of a rocket combustion chamber in which gases are accelerated to higher velocities.

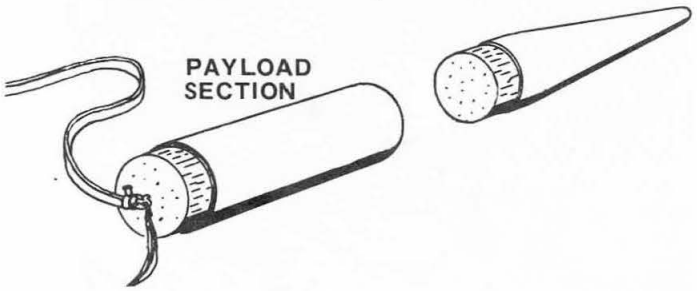


Ohm's Law:
Established in 1827 by physicist George Simon Ohm and states the practical unit of electric resistance (1 ohm) is equal to the resistance of a circuit in which a potential difference of one volt produces a current of one ampere.

Parachute:
A drag-producing device, generally hemispherical (half-sphere) in shape. Parachutes used in model rockets are generally made from light plastic and are used to gently recover the payload package, rocket body, etc.



Payload Section:
The section of the rocket used to carry instruments, biological specimens, etc. This is usually either a spiral wound cardboard tube or clear plastic tube.



Peak Thrust:
The greatest amount of thrust developed by a rocket engine during its firing.

Pound-Second:
A measure of the total impulse produced by a rocket engine.

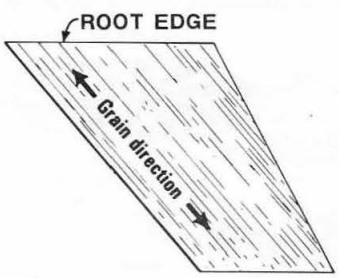
Powered Flight:
The early flight phase when the model rocket engine is providing thrust.

Recovery System:
A device incorporated into a model rocket for the purpose of returning it to the ground in a safe manner. All model rockets must employ a recovery system (such as a parachute).

Recovery Wadding:
Flame resistant tissue packed between the streamer or parachute and model rocket engine protecting the recovery device from hot ejection gases.

Resistance, Electrical:
The opposition offered by a body or substance to the passage of a steady electric current through it.

Root Edge:
The point at which the fin or wing is attached to the body tube.

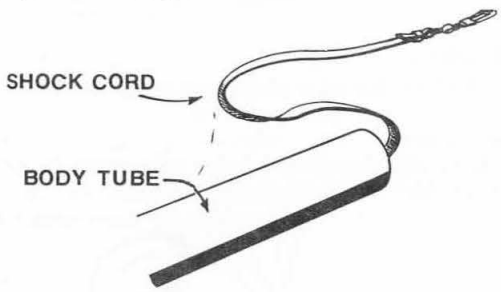


"Model Rocketry Safety Code":
Code establishing rules for safe conduct in model rocketry.

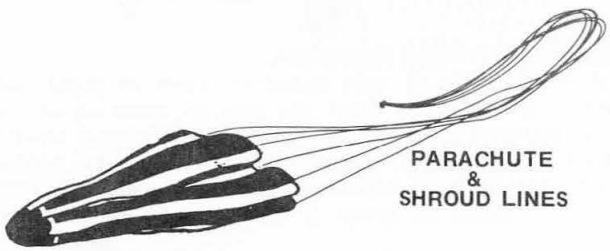
Safety Key:
Special key used to activate a launch system.

Screw Eye:
Metal eye screw, anchored in nose cone or payload compartment base, used to attach parachute and shock cord.

Shock Cord:
The elastic cord used to attach the recovery system to the body of the rocket. Its elasticity absorbs shock when the recovery system deploys.



Shroud Line:
The string or cord used in making parachutes.

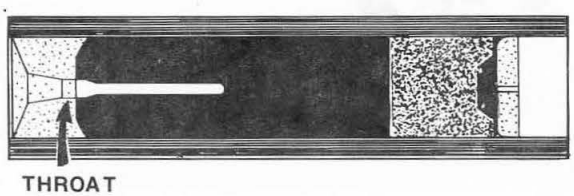


Snap Swivel:
Used to attach parachute or shock cord and allows parachute to be changed quickly from one rocket to another.

Specific Impulse:
A measurement for determining the relative performance of rocket propellants; the measure of energy content per pound of propellant.

Sustainer Engine:
Single or upper stage engine equipped with a delay element and an ejection charge.

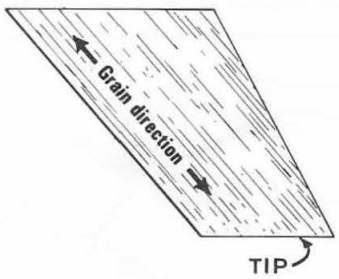
Throat:
The portion of a rocket engine nozzle having the smallest cross-sectional area.



Thrust:
The propulsive force developed by an operating rocket engine caused by the rearward ejection of gases during the combustion process.

Time-Thrust Curve:
A graphic expression of the relation between thrust produced by a rocket engine and time; a graph showing the thrust produced by a rocket engine at each instant of its operation.

Tip:
The outermost end of a fin.



Total Impulse:
The total amount of thrust developed by a rocket engine; determined by measuring the area under the engine's thrust-time curve; or by multiplying the average thrust by the burning time.

Touchdown:
Moment during recovery when rocket makes contact with the earth.

Trailing Edge:
The rear edge of a fin or wing surface.

Volt:
The unit of electromotive force; the electric potential required to make a current of one ampere flow through a resistance of one ohm.

NOTES

SECTION TEST

SECTION I

Review what you have learned in Section One and study the "Model Rocketry Technical Manual" and the Model Rocket Glossary, Part I, before taking this test. Be sure not to look up anything once you start this test. Read the question, and pick your answer from the multiple choice column of answers. Write down the letter preceding your choice. You may start now. Good Luck!

1. My model rockets will be launched with a launch system operated by: _____

   (A) matches and fuses

   (B) electricity

   (C) springs

2. Model rockets must weigh no more than_____ounces at lift off.

   (A) 4 ounces

   (B) 8 ounces

   (C) 16 ounces

   (D) 32 ounces

3. Always remain at least_____feet from a model rocket that is being launched.

   (A) 1-5 feet

   (B) 10-15 feet

   (C) 20-25 feet

4. To be aerodynamically stable, a model rocket must have its:_____

   (A) Center of gravity ahead of its center of pressure

   (B) Center of gravity in the same place as its center of pressure

   (C) Center of gravity behind its center of pressure

5. The total impulse delivered by a B 6-4 engine is _____that delivered by a ½ A 6-2 engine.

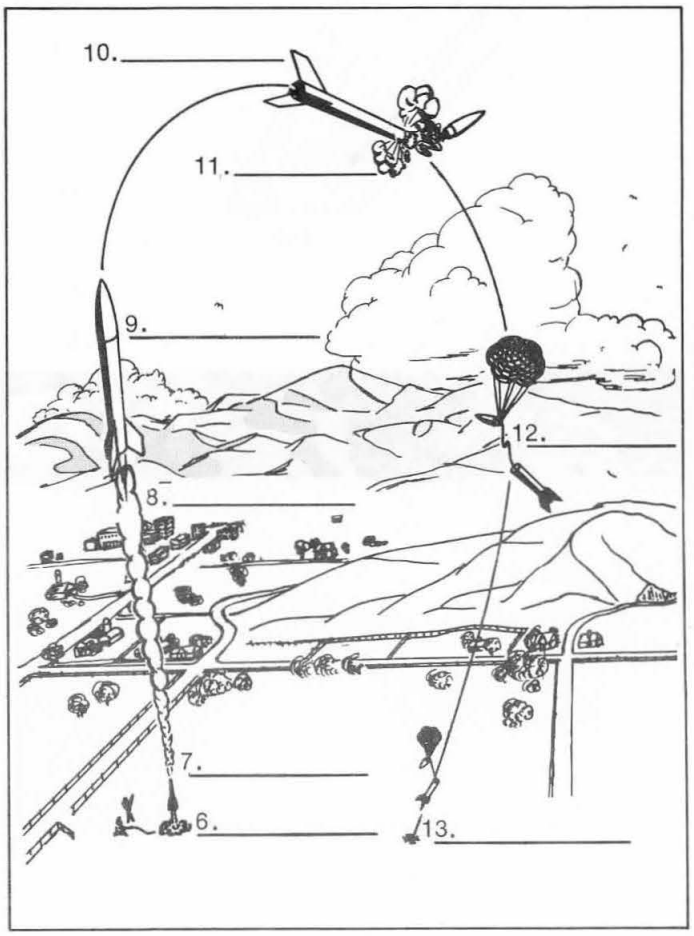
   (A) one-half

   (B) equal to

   (C) twice

   (D) four times

Identify the flight phases of a model rocket.



14. Engine total impulse may be rated in_____.

   (A) Newton-seconds

   (B) Pound-seconds

   (C) Either Newton-seconds or Pound-seconds

   (D) Neither Newton-seconds nor pound-seconds

15. Every launch system must have a safety switch of some type.

   True or false?_____

16. Should you make your own model rocket engines?

   Yes or no?_____

17. Model rockets are made of paper, cardboard tubes, balsa, plastic, steel tubes, and rubber.

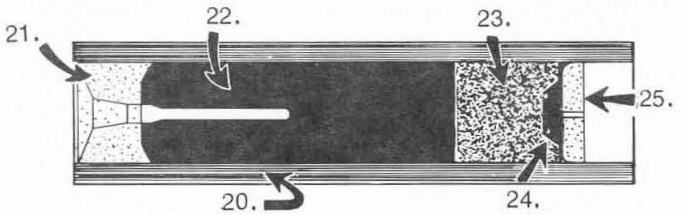
True or false? _____

18. Name two other recovery systems besides parachute recovery.

_____ and _____

19. After the thrust phase of the flight is over, the rocket is in the _____ phase before the ejection charge operates.

Identify the engine parts indicated in the following drawing:



20. _____ 21. _____

22. _____ 23. _____

24. _____ 25. _____

37. The point in the orbit of a satellite at which the satellite is farthest from Earth is called the _____.

38. The portion of a rocket engine nozzle with the smallest cross-sectional area is the _____.

39. The tiny, flat-jawed alligator clip used to attach the ignition system to the igniter is called the _____.

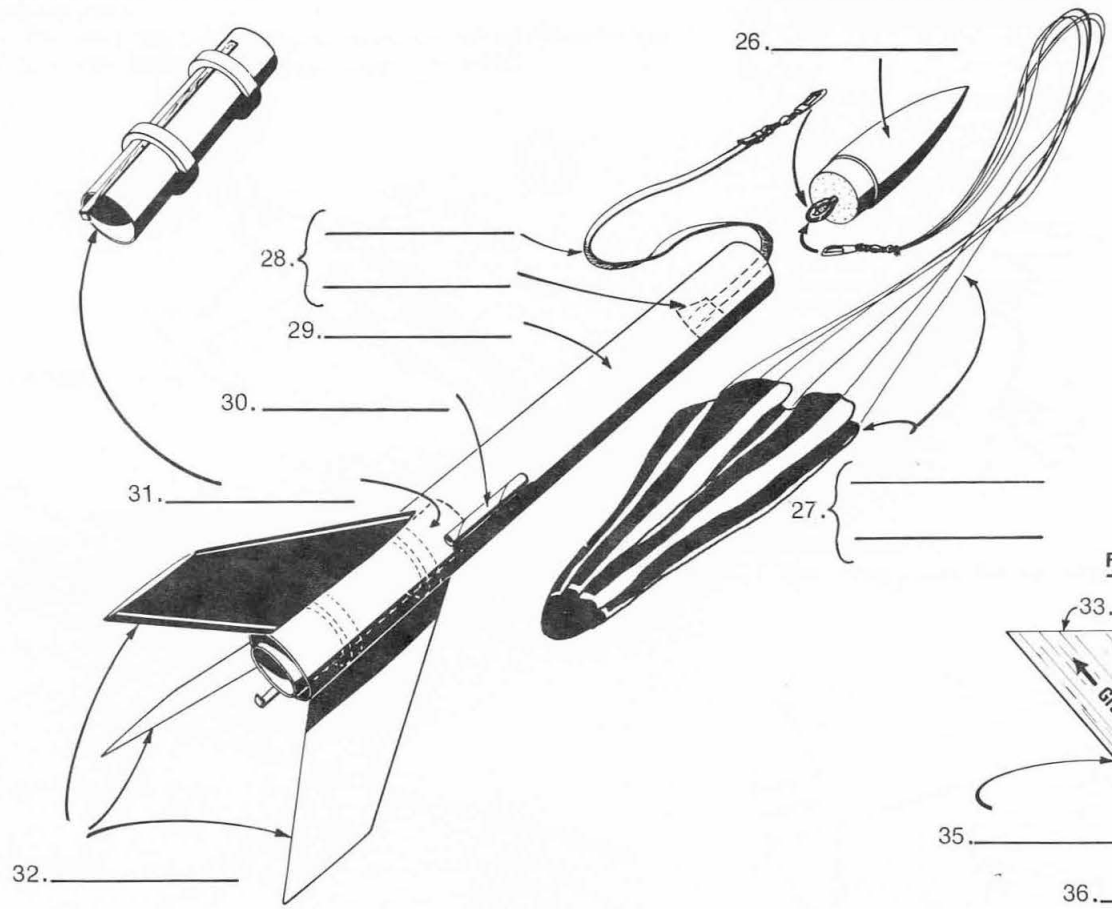
40. "For every action there is an equal and opposite reaction," is Newton's _____ Law.

ANSWERS

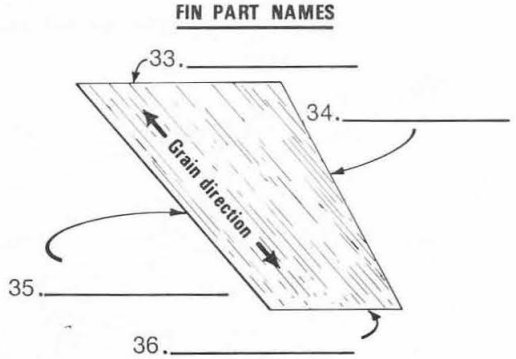
1. (B)
2. (C)
3. (B)
4. (A)
5. (D)
6. Ignition
7. Lift-off
8. Thrust phase
9. Coast period
10. Apogee
11. Ejection charge
12. Parachute deployment
13. Recovery
14. (C)
15. T
16. No
17. F
18. featherweight, tumble, streamer, helicopter, glider
19. coast
20. Paper casing
21. Nozzle
22. Propellant
23. Smoke tracking and delay element
24. Ejection charge
25. Ejection charge retainer
26. Nose cone
27. Parachute and shroud lines
28. Shock cord and mount
29. Body tube
30. Launching lug
31. Engine holder assembly
32. Fins
33. Root edge
34. Trailing edge
35. Leading edge
36. Tip
37. Apogee
38. Throat
39. Micro-clip
40. Third

ANSWERS

LABEL THE PARTS:



FIN PART NAMES



NOTES

SECTION II

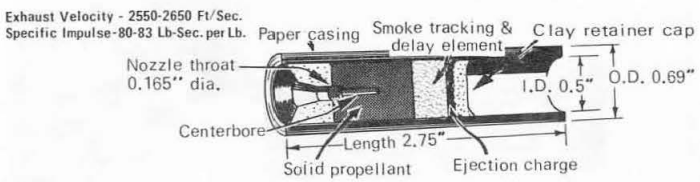
ADVANCED MODEL ROCKETRY

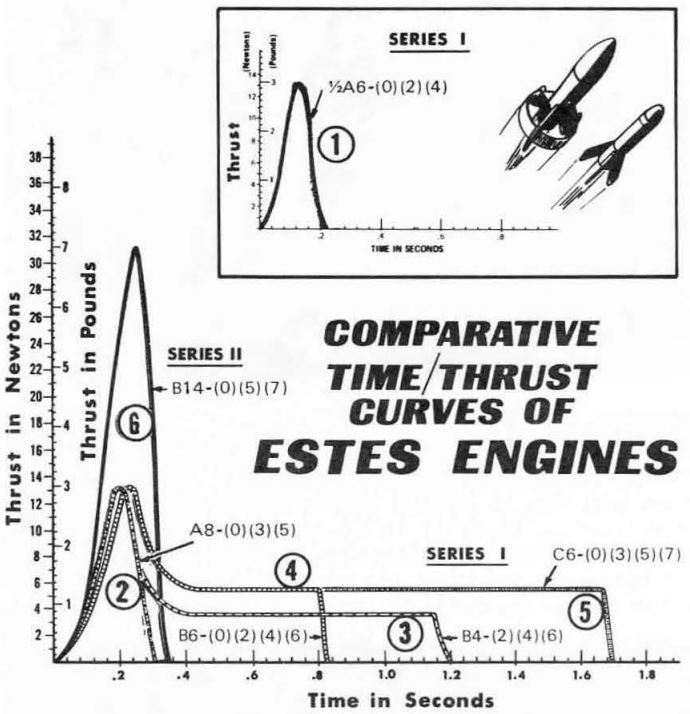
Continue your efforts toward becoming an Expert rocketeer by following Section II of the Model Rocketry Study Guide . Each new project will advance your knowledge of model rocket science.

T-10 Learn about model rocket stability by studying Technical Report TR-1, "Rocket Stability". By using the methods and techniques suggested, you will be assured of safe and stable flights. Pre-flight stability tests, such as the swing test, will contribute to your experience and will be of later value in testing rockets of your own design.

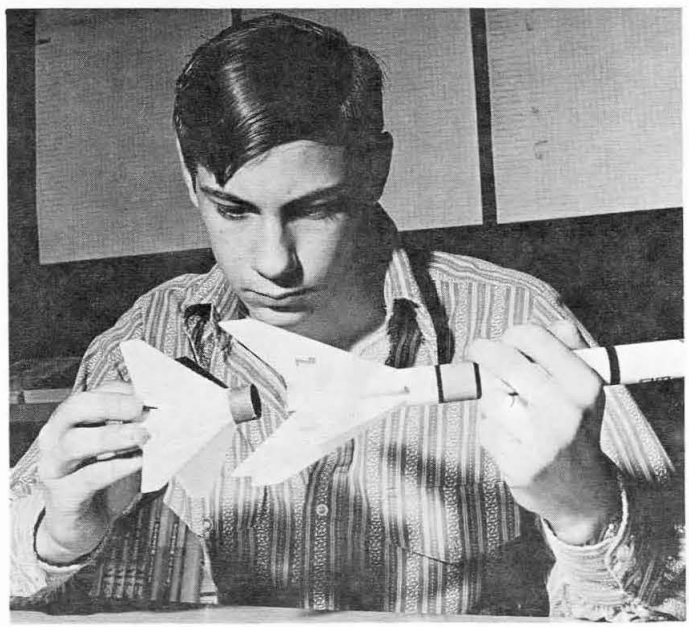
T-9 Read Technical Note TN-1, "Rocket Engine Design", and TN-2, "Model Rocket Engine Performance", to gain a better understanding of how the various types of model rocket engines function. Make several flights of a single stage Estes model rocket using different types of engines and compare the flights. The information gained from your observations will be of future assistance when you are ready to launch models of more advanced designs.

CROSS-SECTION VIEW B14-5 ENGINE





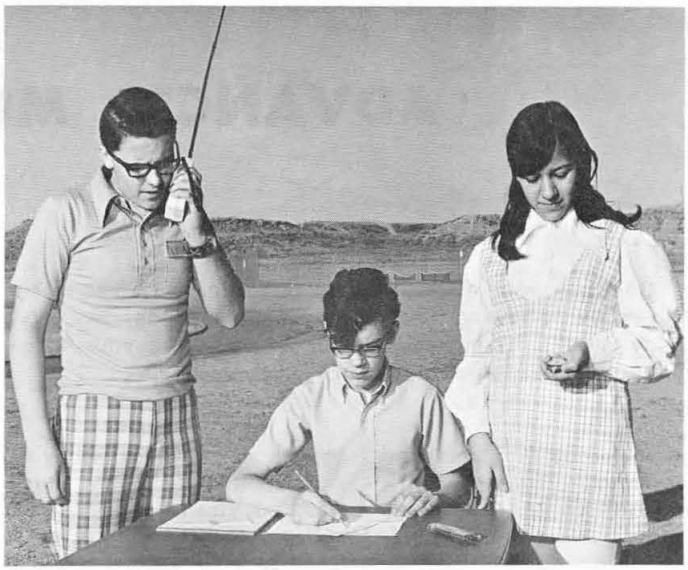
T-8 For maximum altitude and performance, build a multi-stage vehicle like the Estes Beta or Avenger. Study Technical Report TR-2, "Multi-Staging", and learn about booster engines, stage-to-stage coupling, in-flight ignition, and reliable separation.



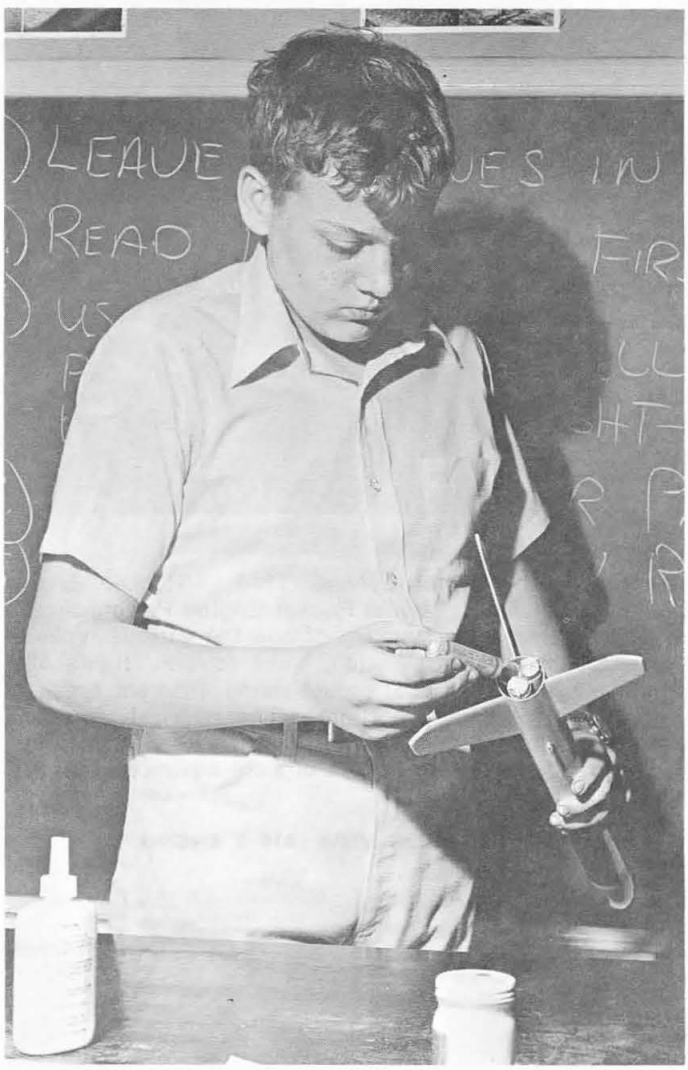
Don't forget to follow the assembly and flight instructions carefully. Be sure to launch your model from an area with a large recovery field as staged rockets can attain tremendous heights.

T-7 To find out how high your rockets go, read Technical Report TR-3, "Altitude Tracking." This report will show you how to perform accurate tracking and altitude determination. Build an Altiscope or construct a tracking device from your own supplies. Launch several rockets and determine their altitudes through either single station or two station tracking.

Once you have mastered altitude tracking, your data reduction operations can be improved with flight sheets, quickie computers, stop watches, and walkie-talkies.



T-6 Explore the potential of using clusters of engines for increased power. Study Technical Report TR-6, "Cluster Techniques", and learn about the various engine cluster configurations and cluster ignition techniques.



Construct and fly a rocket like the Estes Scrambler which features a 3-engine cluster.

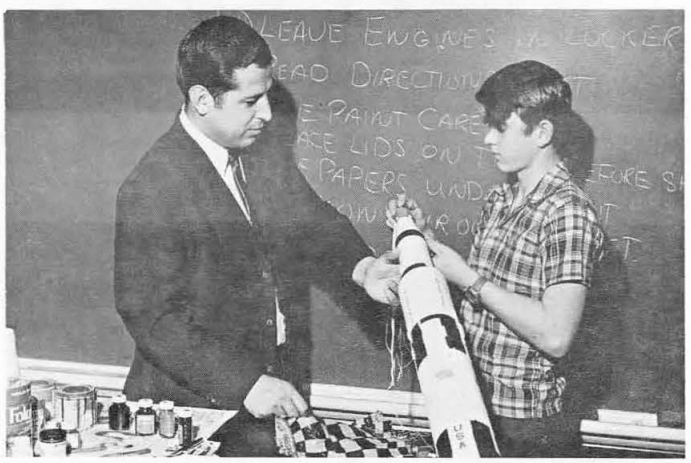
T-5 Now that you have experience in single stage construction, multi-staging, and cluster techniques, construct and fly a payload rocket using one of these propulsion systems. Choose your payload first, then select the type of rocket needed to launch it.

Single and multi-stage rockets which feature a payload compartment are excellent for insect payloads. Cluster rockets are especially suited for lofting a large cargo such as a raw egg. Two-stage booster vehicles such as the Delta and Omega are excellent for carrying the Estes "Camroc" and "Cineroc" aerial cameras.

The mighty Estes "D" engine has the capability for carrying large, heavy payloads to extremely high altitudes. You should consider this "workhorse" when planning your payload project. For complete information on the "D" engine refer to the current Estes catalog and to the engine instructions packed in each "D" engine carton.

When constructing your payload vehicle take special care in preparing and protecting the all-important payload from possible acceleration or recovery damage. Remember to launch your rocket from an area with a large recovery field to assure the prompt return of your payload.

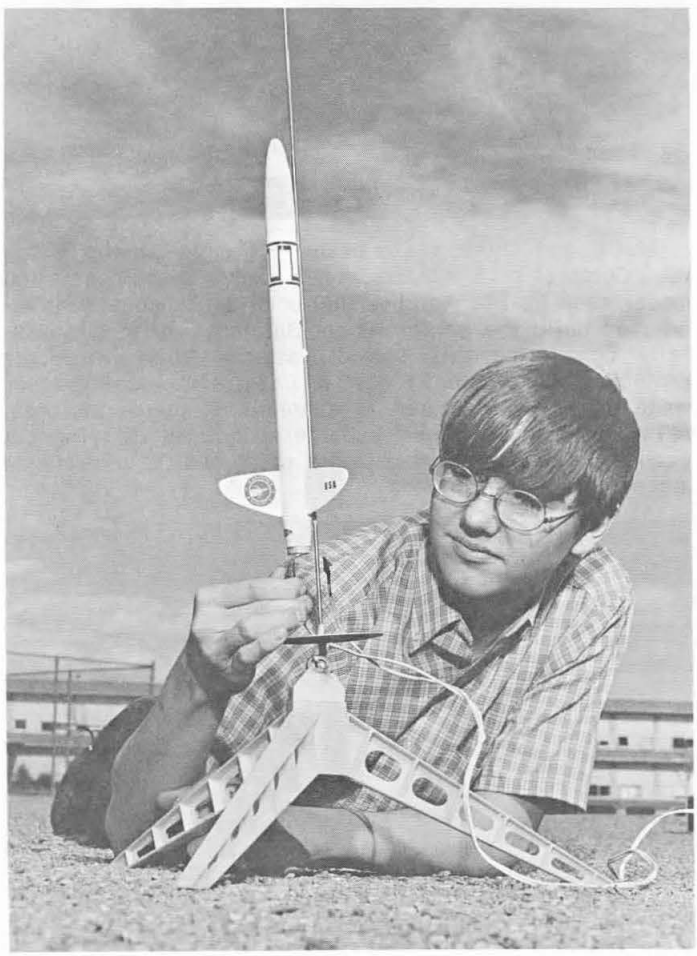
T-4 Scale model rocketry involves the design and construction of miniature rockets which are replicas of full-sized rockets. Scaling is one of model rocketry's most challenging and rewarding areas and requires patience, attention to detail, craftsmanship, and desire.



Build and fly a scale model kit such as the Estes WAC Corporal or Sandhawk. Then tackle a more detailed model such as the Aerobee 300 or V-2. As your skill increases build the Saturn 1B or Saturn V. After successfully completing this project, attempt your own scale project. Choose a real rocket or missile for scaling, then write to its manufacturer for dimensions, plans, pictures, paint pattern, and flight substantiation. By carrying out such a project you will obtain a great deal of experience and much satisfaction.

T-3 Model rocket competition is one of the most exciting forms of model rocket activity. Read the Model Rocket Contest Guide and learn about Maximum Altitude, Parachute Duration, Glide Duration, Drag Racing, Spot Landing, Set Altitude, Payload Handling, Scale, Craftsmanship, and Research and Development events.

Construct and fly a high performance competition model like the Estes Astron Sprint and compare its altitude and duration times to other single stage rockets using the same type of engine.

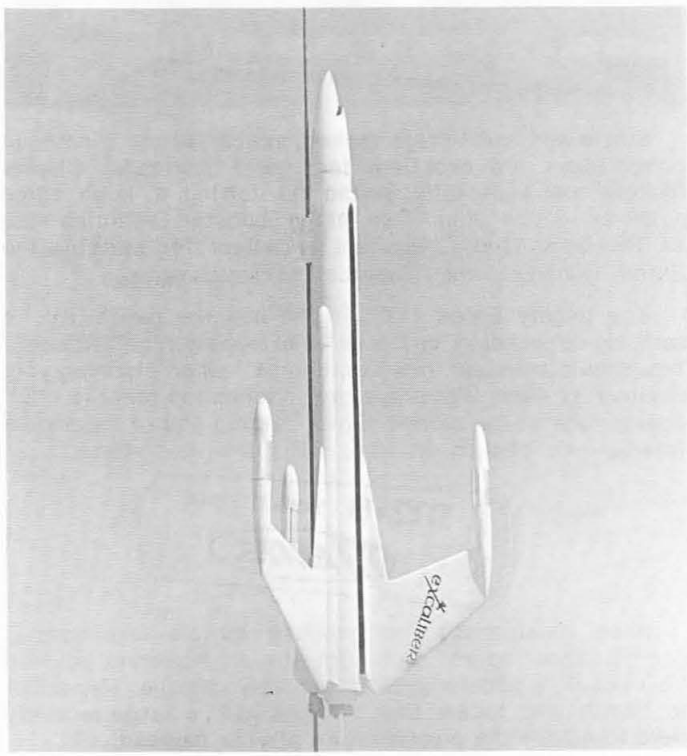


T-2 Learning how to design your own rockets is one of the most important steps to becoming an Expert rocketeer. You have built and flown various types of model rockets and are now ready to develop your own designs. Read Technical Report TR-9, "Designing Stable Rockets", to learn about center of gravity and center of pressure calculations, nose cone shapes, fin area determination, and other stability concepts.

When launching rockets of your own design be sure to follow the rule in the "Model Rocketry Safety Code" which deals with the testing of unproven designs or methods.

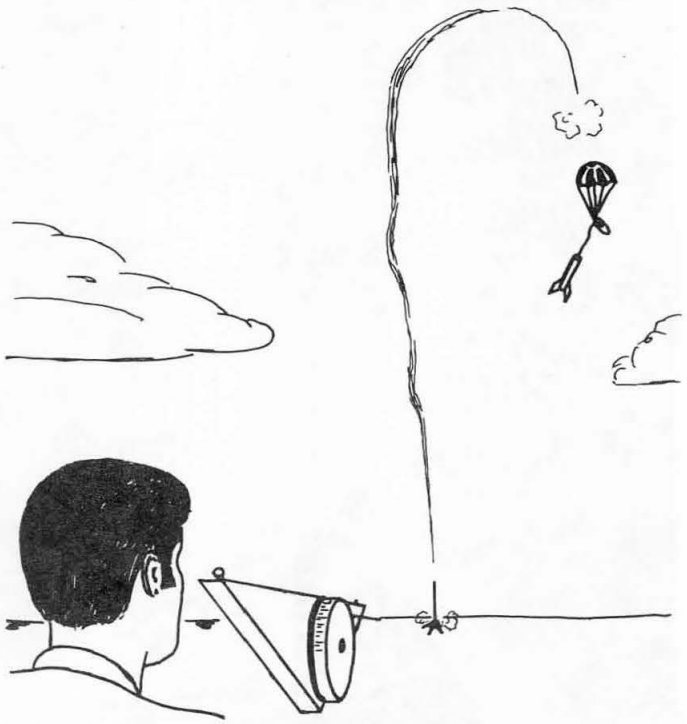
"14. Pre-Launch Test - When conducting research activities with unproven designs or methods, I will, when possible, determine their reliability through pre-launch tests. I will conduct launchings of unproven designs in complete isolation from persons not participating in the actual launching."

Remember, data reduction is very important to design testing as it can be reviewed for future reference.

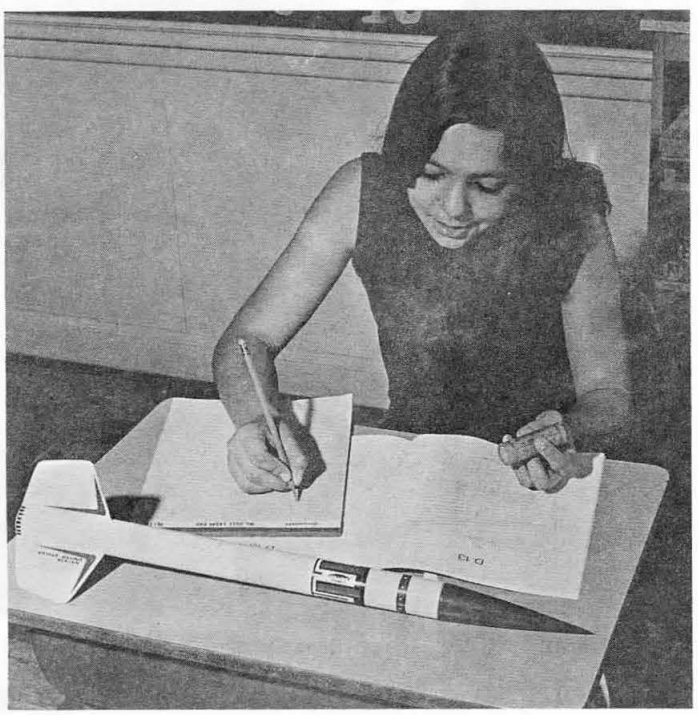


T-1 Your model rocket activities can now advance in many directions. As you continue on the road to becoming an Expert rocketeer you may wish to explore the following areas:

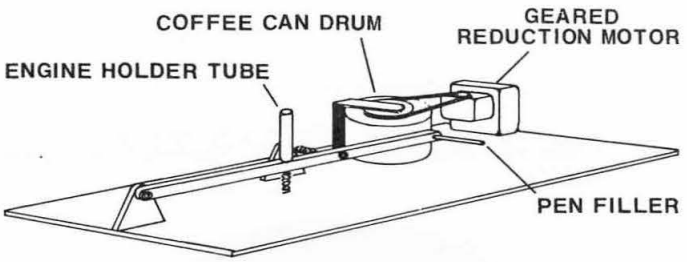
a. Weather and atmospheric tests.



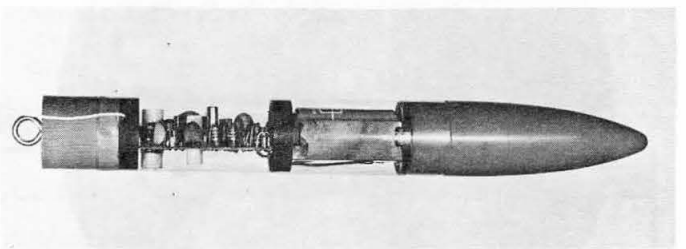
b. Studies in the mathematics of rocket flight including investigations in acceleration, trajectory, drag, etc. Refer to Technical Reports TR-10, "Altitude Prediction Charts", and TR-11, "Aerodynamic Drag of Model Rockets".



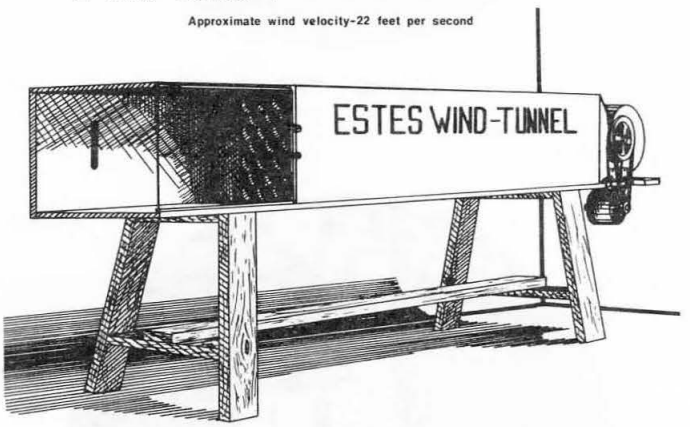
c. Construction of a static test stand to secure time-thrust curve information for various types of model rocket engines.



d. For radio-telemetry and payload instrumentation experiments try Estes Rocketronics.



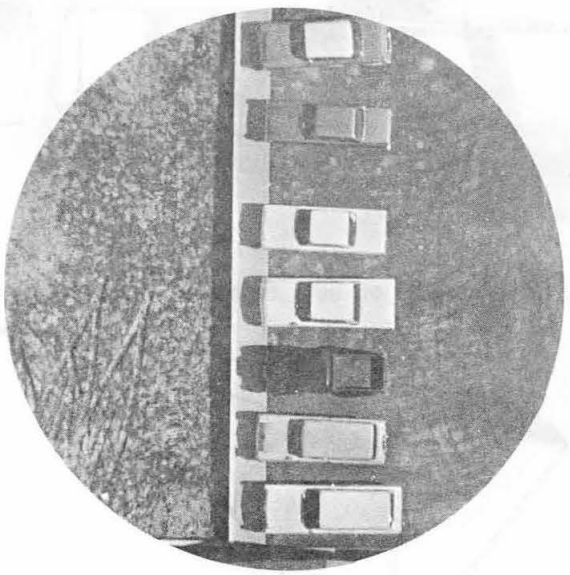
e. Construction of a wind tunnel for pre-flight stability tests. Refer to Technical Report TR-5, "Building A Wind Tunnel".



f. Development of new types of recovery devices.

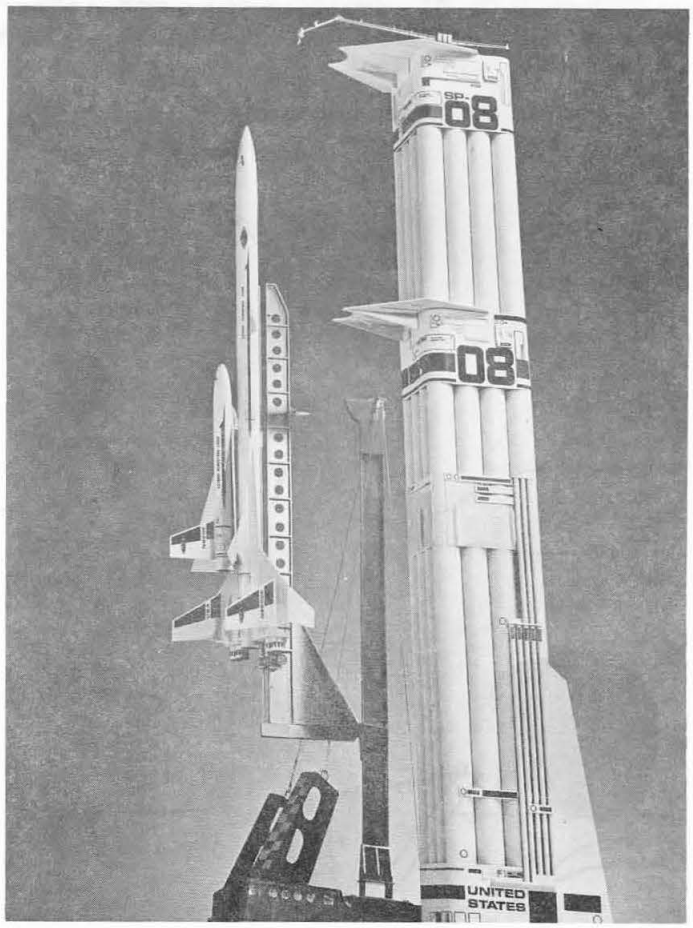
g. Photc interpretation using the "Camroc" or "Cineroc".

CAMROC PHOTO



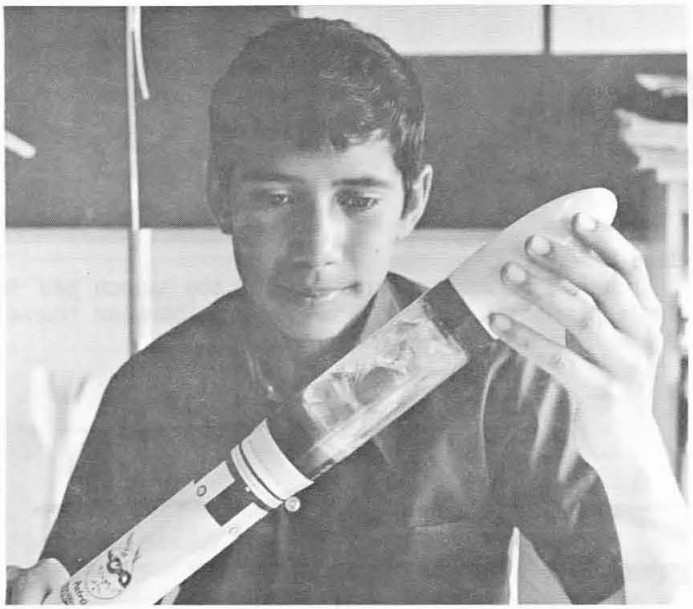
CAMROC PHOTO (ENLARGED)

h. Construction of a model rocket gantry or launch tower.



i. Construction of an underwater launch facility.

j. Payload experimentation using goldfish, reptile, or amphibian. Take the greatest care possible for the passenger's safety, comfort, and well-being.



k. Development of a two station, 3-dimensional tracking system and the construction of theodolite tracking devices.

l. Conduct full-fledged research and development programs into previously unexplored areas of model rocket science.

NOTES

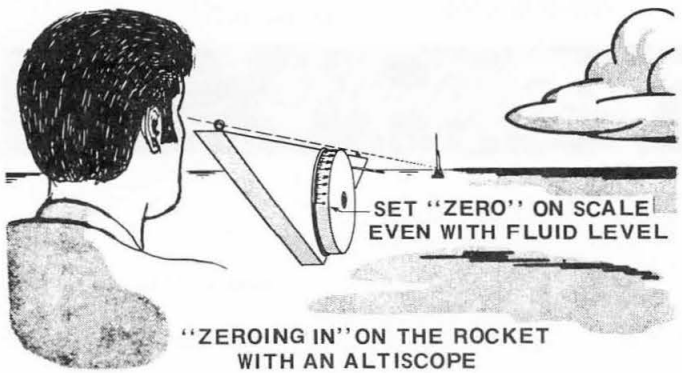
GLOSSARY

ADVANCED TERMS

Acceleration:
The rate of increase in the speed of an object. Acceleration is generally measured in terms of "g's", one "g" being the rate at which a dropped object accelerates under the force of gravity, or 32.2 feet per second per second.

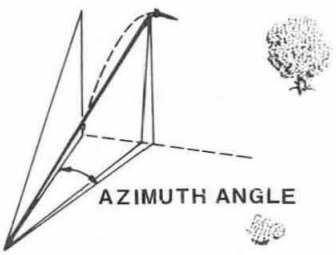
Accelerometer:
A device for the measurement of acceleration.

Altiscope:
Device used to determine the elevation angle of a model rocket which is used to calculate the altitude of a model rocket.

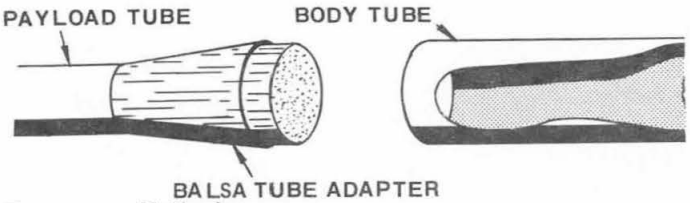


"ZEROING IN" ON THE ROCKET WITH AN ALTISCOPE

Azimuth Angle:
A direction expressed as a horizontal angle from a given reference point.

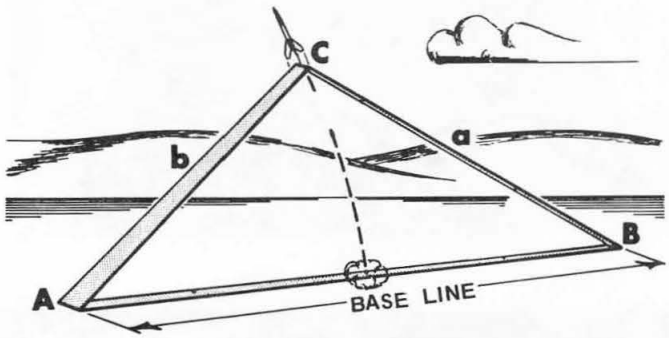


Balsa Adapter:
Round tapered balsa fitting used to connect body tubes of different diameters.



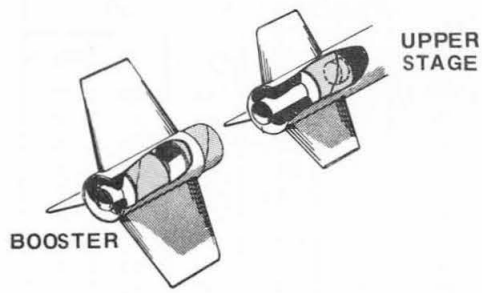
Barrowman Method:
Mathematical method used to calculate the center of pressure of a model rocket.

Base Line:
Distance between the tracker and the launch pad in single station tracking or the distance between tracker #1 and tracker #2 in two station tracking.



Blow-through:
An engine failure in which the propellant is blown out the forward end of the casing. Lower stage engines have a certain amount of blow-through designed into them to provide hot gases for the ignition of the next stage.

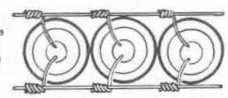
Booster:
A separate, detachable portion of a rocket containing its own engine; used to impart an initial velocity to the rocket before the ignition of the upper stage engine of the rocket. The booster separates from the rocket when the next engine is ignited. For further information see Technical Report TR-2.



Burnout Velocity:
The speed of a rocket at the time all propellant has been totally consumed.

Burnout Weight:
The weight of a model rocket after all propellant has been expended.

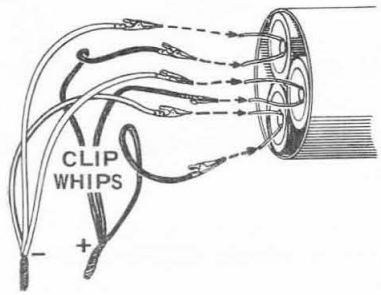
Buss Bar:
Length of low resistance wire to which igniters are attached for the parallel or cluster ignition of engines.



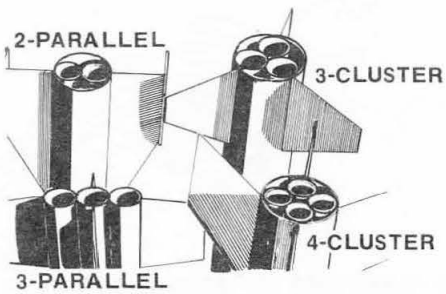
Center of Pressure:
The center for all external aerodynamic forces on the complete rocket including the body and fins.

Chamber Pressure:
The pressure exerted on the walls of the combustion chamber of a rocket engine by the burning propellant gases; usually measured in pounds per square inch.

Clip Whip:
Micro-clip assembly used to ignite a cluster of engines.



Cluster:
A group of rocket engines which work as a unit. The total thrust of a clustered unit is equal to the thrust of all the individual engines added together.

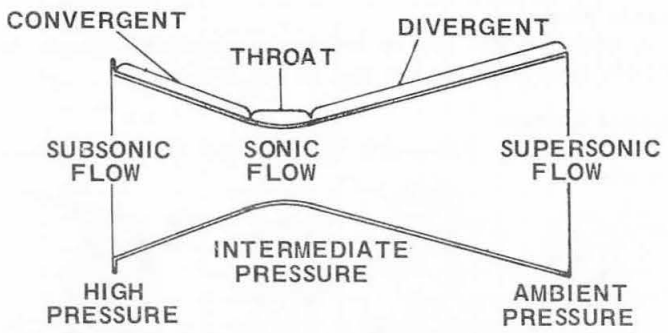


Configuration:
The external form or contour.

Data Reduction:
Process of calculating the performance of a model, such as its peak altitude or its flight duration.

Deceleration:
The rate of decrease in the speed of an object. Deceleration is generally measured in "g's".

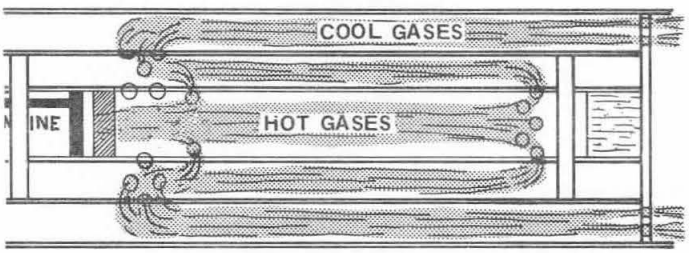
de Laval Nozzle:
The nozzle used in high performance rocket engines consisting of three separate sections: a convergent section; a throat section; and a divergent section.



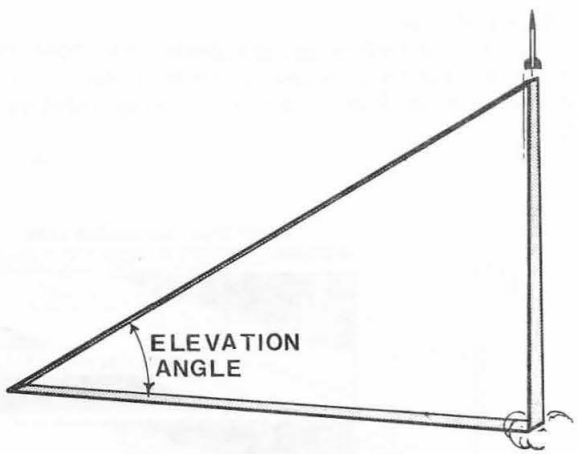
Drag:
Aerodynamic forces acting to slow an object in flight. Because of their low weight to area ratio and high velocities, model rockets are especially susceptible to these forces.

Drag Racing:
Competition in which two competitors race their rockets against each other. Points are distributed as follows: First off the pad receives one point, lowest altitude receives one point, and last down receives one point. The competitor achieving at least two points wins.

Ducted Ejection:
Method of ducting ejection gases through tubes to a particular area; system of ducting hot ejection gases until they are cool before initiating the deployment of the recovery device. Eliminates the need for recovery wadding.



Elevation Angle:
Vertical angle recorded by trackers used to compute the altitude of a model.

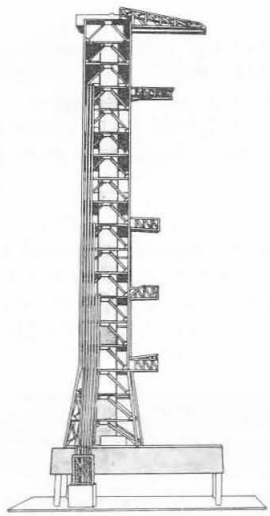


Exhaust Velocity:
The speed of the exhaust gases of a rocket engine.

Flight Duration:
The length of time during which a model rocket is airborne.

Flight Substantiation:
Official data stating the proven flight characteristics of a NASA vehicle or other professional rocket.

Gantry:
A crane-like structure with platforms on different levels used to erect, assemble, and service large rockets or missiles. It is located next to the missile or rocket during launch preparations, but is rolled away before firing.

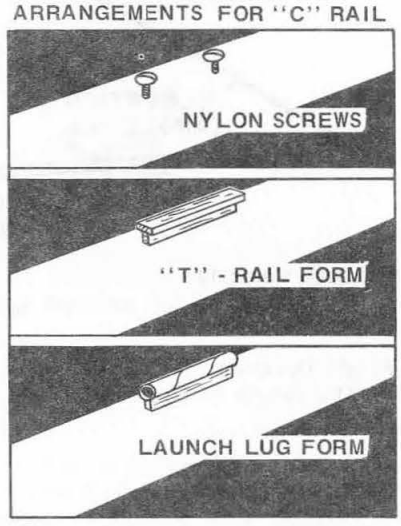


Horizontal:
Level or parallel to the horizon.

Krushnik Effect:
The loss of effective thrust from a model rocket engine occuring when the engine is recessed forward in the body tube more than one diameter of the body.

Launch Rail ("C" rail):
Metal rail with a hollow square shape; its cross section forming a squared C; used to guide a model during its first few feet of flight until stabilizing velocity is reached.

POSSIBLE LAUNCH LUG ARRANGEMENTS FOR "C" RAIL



Loaded Weight:
The weight of a model rocket with loaded engine, igniter, wadding, and recovery device.

Mach Number:
The ratio of the speed of an object to that of sound in the medium being considered. At sea level in air at the normal atmospheric pressure a body moving at a Mach number of one (Mach 1.0) would have a velocity of approximately 1100 feet per second, the speed of sound in the air under those conditions.

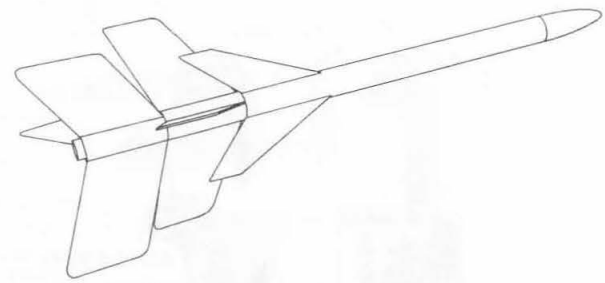
Maximum Altitude:
Competition in which participants, using the same type engine, attempt to send their rockets to the highest altitude possible.

Metric System:
International system of weights and measurements.

Moment:
Determined by multiplying force by distance from a reference point.

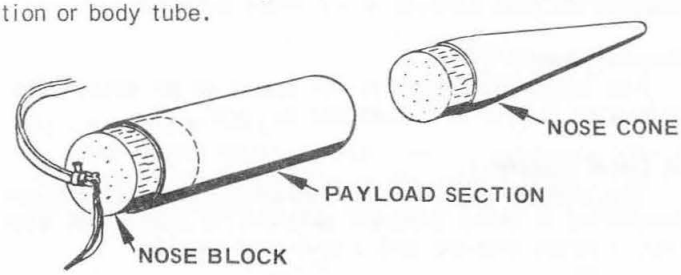
Momentum:
A property of a moving object equal to its velocity times its mass.

Multi-Stage Rocket:
A rocket having two or more engines, each used during a different portion of the flight; each stage being dropped as soon as its engine has been exhausted.



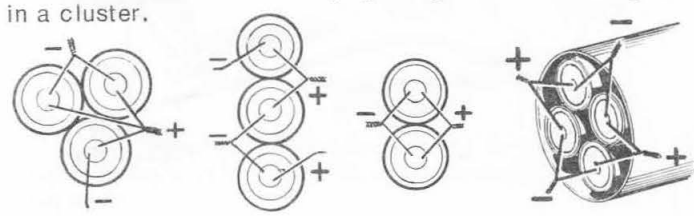
National Association of Rocketry, N.A.R.:
Founded in 1957 to perpetuate individual and organized model rocketry, to develop standards and safety codes, to establish standardized competition, and to sponsor national championships.

Nose Block (Bulkhead):
Round balsa fitting used to block off a payload section or body tube.

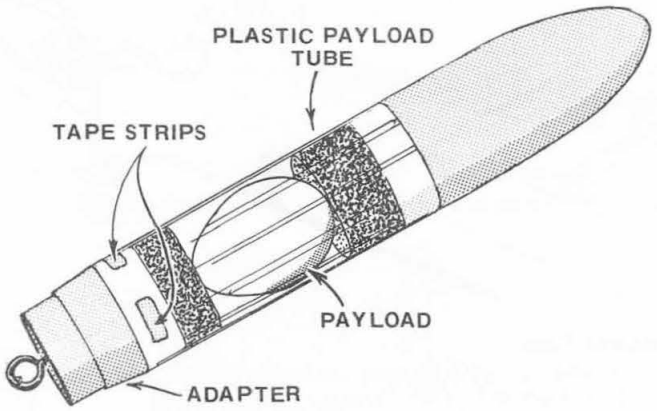


Nozzle Blow:
A model rocket engine failure in which the nozzle is forcibly expelled from the rear of the engine.

Parallel Ignition:
Method of simultaneously igniting two or more engines in a cluster.

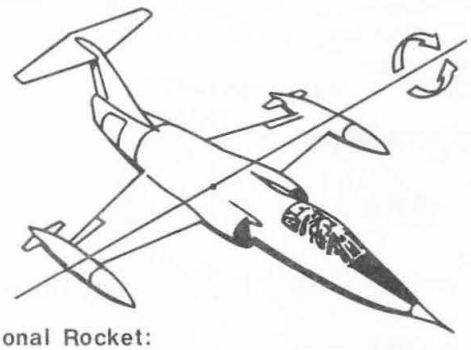


Payload:
The load to be lifted by the rocket; usually not a functioning part of the rocket.



Payload Handling:
Competition in which participants attempt to launch payload carrying rockets to the highest altitude possible and to bring the payload back undamaged.

Pitch:
Rotational movement around the lateral axis of the craft.

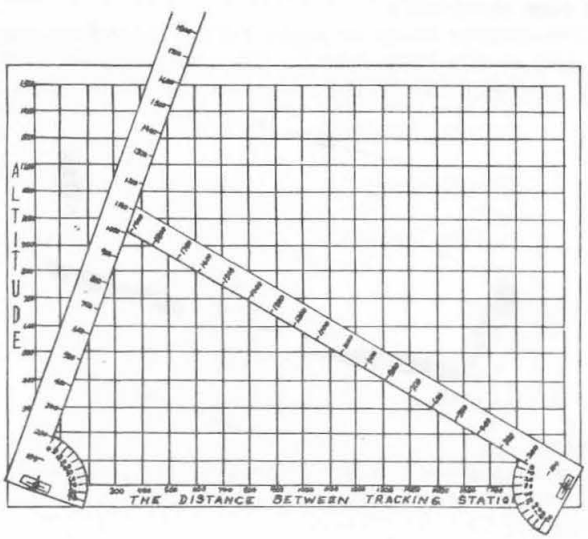


Professional Rocket:
NASA vehicle or rocket built by government agency, aerospace industry, or professional scientists.

Propellant Weight:
The weight of the propellant in a rocket engine.

Propulsion:
Act of propelling or of driving forward.

2-D (Quickie) Computer:
Two-dimensional computer for quick calculations of altitude using elevation angles.



Research & Development (R & D):
Process of planned experimentation leading toward a predetermined goal or a competitive event in which participants present special R & D projects.

Reynolds Number:
A correction factor applied to analysis of the fluid flow about scale models used in wind tunnel tests to determine the results which are to be expected of the flow about full-scale models; a dimensionless ratio. (See TR-11 for more information.)

Rocketronics:
Estes trade name for the science of model rocket electronics and telemetry.

Rocketus eatumupus:
Tree or large shrub which catches and "eats" model rockets.

The Rocketus eatumupus

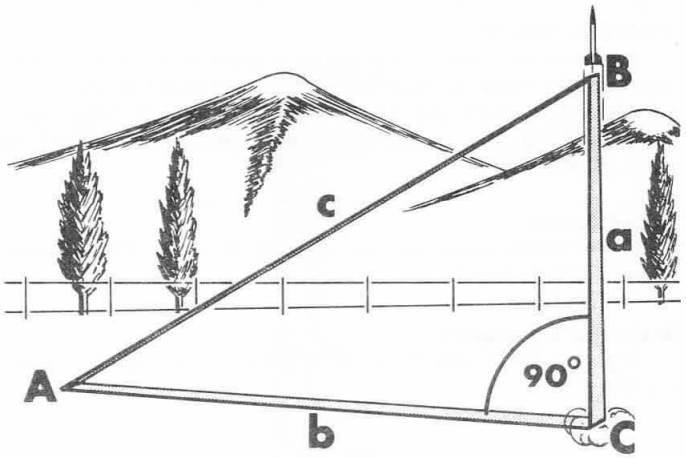
Roll:
Rotational movement of a craft about its longitudinal axis.

Scaling:
Process of making a plan for a model which is a precisely detailed replica of the full-sized original.

Set Altitude:
Competition in which the participant predicts the altitude his rocket will reach.

Sine:
The trigonometric function that for an acute angle in a right triangle is the ratio of the side opposite the angle to the hypotenuse.

Single Station Tracking:
Tracking system employing only one tracker. It is the least expensive and accurate of the tracking methods.



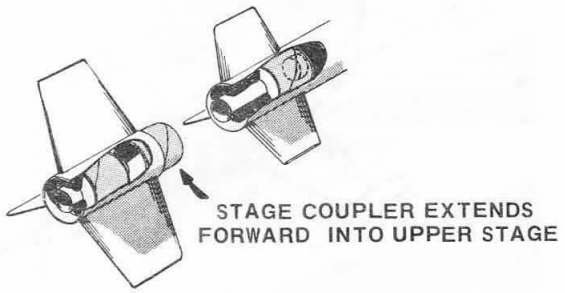
Solid Propellant:
The mixture of fuel and oxidizer in solid form which burns to produce the hot gases used in generating thrust.

Sounding Rocket:
A research rocket used to obtain data on the upper atmosphere.

Spot Landing:
Competition in which the participant attempts to have his rocket touch down at a predetermined spot.

Stability, Inherent:
The tendency of a rocket having the proper center of gravity/center of pressure relationship to maintain a straight course despite rotating forces caused by variations in design and outside disturbances.

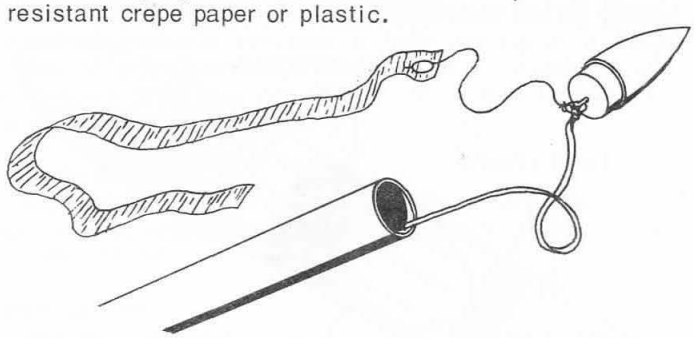
Stage Coupler:
Tubing used to temporarily attach one stage to another.



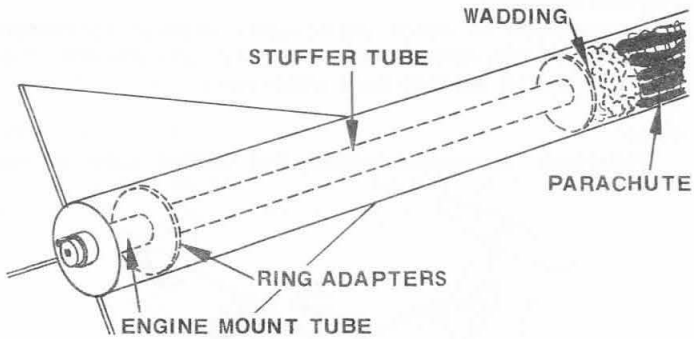
Static Firing:
A test of a rocket engine in which the engine is restrained from leaving the ground. Static firings are conducted for the purpose of determining an engine's performance and reliability characteristics.

Static Test Stand:
Device used to measure an engine's performance and reliability characteristics and/or generating a thrust-time curve.

Streamer:
Recovery system made from a narrow piece of flame-resistant crepe paper or plastic.

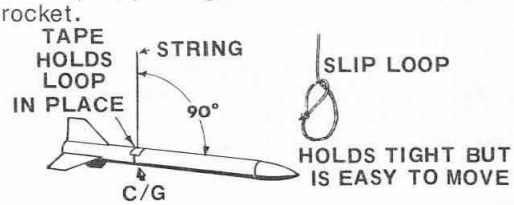


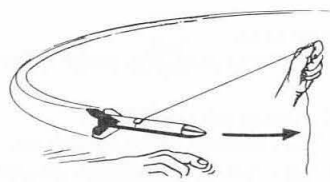
Stuffer Tube:
A smaller tube placed inside a larger body tube used to duct ejection gases to a particular area.



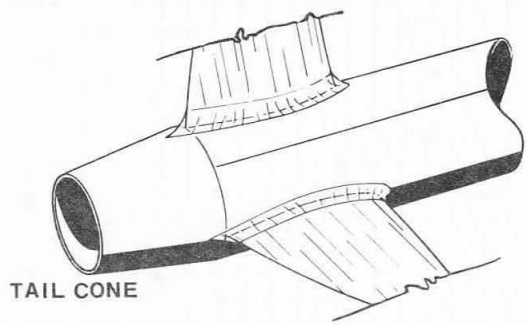
Summation:
The sum total or aggregate.

Swing Test:
Simple, pre-flight test to check the stability of a model rocket.





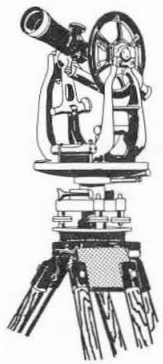
Tail cone (boat-tail):
Cone-shaped balsa or paper fitting extending from the rear end of the body tube to the engine mount, reducing body tube diameter of the engine. Used to decrease drag.



Tangent:
The trigonometric function that for an acute angle in a right triangle is the ratio of the side opposite to the side adjacent.

Telemetry:
The science of sending data from a rocket back to earth.

Theodolite:
An optical instrument for measuring horizontal and/or vertical angles with precision.



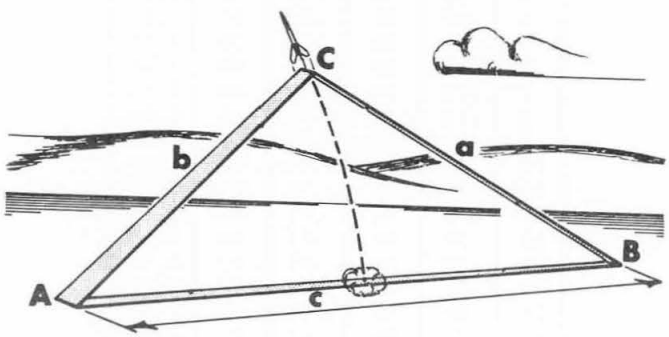
Three-Dimensional Tracking:
Two station tracking system measuring both elevation and azimuth angles. This is the most accurate type of tracking system.

Thrust Duration:
The length of time during which a model rocket produces thrust.

Trade-Offs:
Compromises made in model rocket design involving weight, diameter, and drag.

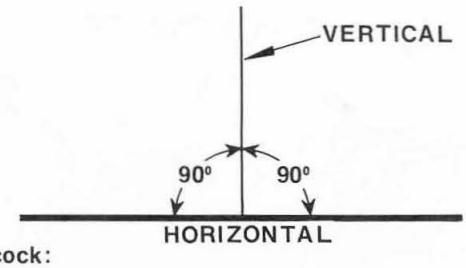
Trajectory:
The path followed by a ballistic object. Strictly speaking, a model rocket does not follow a trajectory as its direction and rate of travel are strongly influenced by atmospheric conditions.

Two Station Tracking:
Tracking system employing two trackers. It is more accurate than single station tracking.

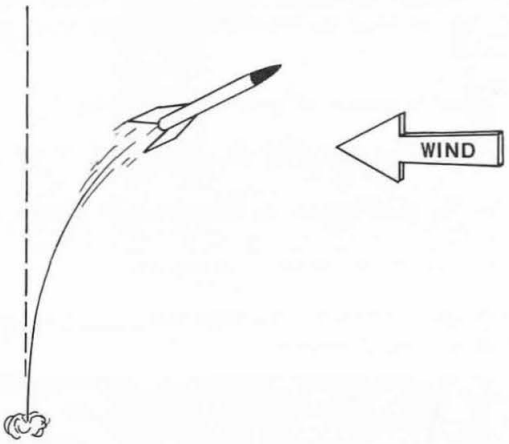


Velocity:
Speed or rate of motion.

Vertical:
At right angles to the horizontal.



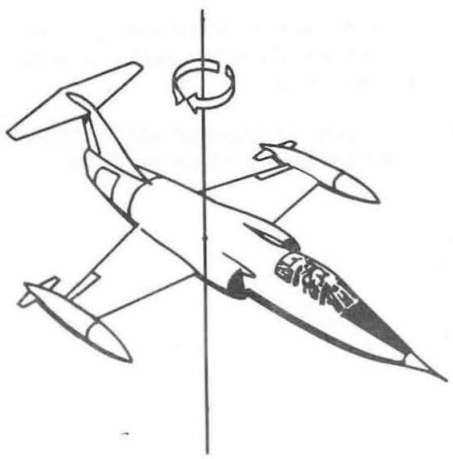
Weathercock:
To turn into the wind away from a vertical path.



"Whatchamacallit":
Any object for which a rocketeer cannot remember the name.

Wind Tunnel:
Device used to test the stability and flight characteristics of various aerodynamic structures.

Yaw:
Rotation of a craft about its vertical axis.



SECTION TEST

SECTION II

Review what you have studied in Section II and study the Model Rocket Glossary, Part Two, before you start this test. Do not look up anything once you start the test. Good luck!

1. The rocket's center of gravity should be: _____

   (A) Behind its center of pressure

   (B) In the same place as its center of pressure

   (C) Ahead of its center of pressure

2. A C6-3 engine has a total impulse _____ as great as that of a ½ A6-2 engine.

   (A) the same

   (B) one-half

   (C) four times

   (D) eight times

   (E) sixteen times

3. A C6-3 engine has a total impulse of _____ Newton-seconds.

   (A) 0.625 Newton-seconds

   (B) 1.25 Newton-seconds

   (C) 2.50 Newton-seconds

   (D) 5.00 Newton-seconds

   (E) 10.00 Newton-seconds

   (F) 20.00 Newton-seconds

4. A C6-3 engine has a delay element which operates for _____ seconds after the rocket's engine has stopped producing thrust.

5. Select the lower or booster stage engines from this list by marking out all other engines:
   ¼ A3-2
   ½ A6-0
   A8-0
   B4-2
   B4-4
   B14-0
   C6-0
   D12-0
   D12-5

6. A mulit-stage model rocket's last stage must be stable, but it is not necessary for the entire rocket to be stable before launch. True or false? _____

7. Calculate the height of this model rocket at point B. _____ feet.

   Given: baseline b = 300 ft.
   $\angle A = 31^\circ$

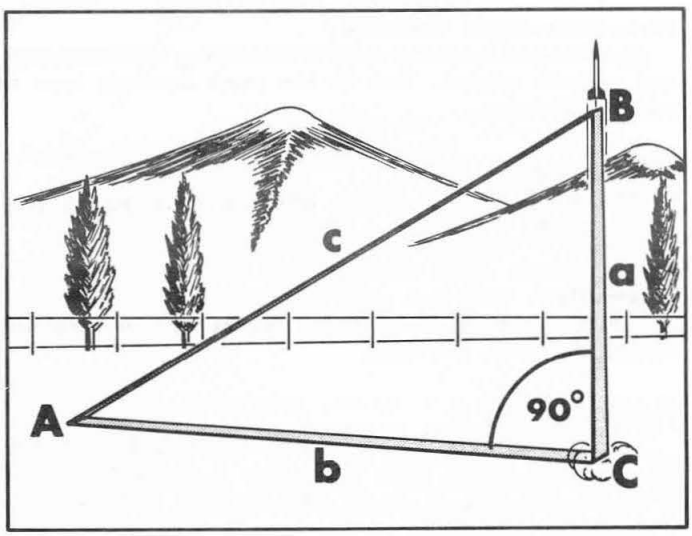


TABLE OF TANGENTS

Angle	Tan.	Angle	Tan.	Angle	Tan.
1°	.02	28°	.53	54°	1.38
2	.03	29	.55	55	1.43
3	.05	30	.58	56	1.48
4	.07	31	.60	57	1.54
5	.09	32	.62	58	1.60
6	.11	33	.65	59	1.66
7	.12	34	.67	60	1.73
8	.14	35	.70	61	1.80
9	.16	36	.73	62	1.88
10	.18	37	.75	63	1.96
11	.19	38	.78	64	2.05
12	.21	39	.81	65	2.14
13	.23	40	.84	66	2.25
14	.25	41	.87	67	2.36
15	.27	42	.90	68	2.48
16	.29	43	.93	69	2.61
17	.31	44	.97	70	2.75
18	.32	45	1.00	71	2.90
19	.34	46	1.04	72	3.08
20	.36	47	1.07	73	3.27
21	.38	48	1.11	74	3.49
22	.40	49	1.15	75	3.73
23	.42	50	1.19	76	4.01
24	.45	51	1.23	77	4.33
25	.47	52	1.28	78	4.70
26	.49	53	1.33	79	5.14
27	.51			80	5.67

8. To launch a model rocket which is powered by a cluster of engines, the igniters should be attached to the ignition system in_____.

   (A) series

   (B) parallel

9. A cluster of four B6-4 engines will produce_____ times as much total impulse as a cluster of two A8-3 engines.

10. When building your payload-carrying rockets to use D engines, the models should be made very strong to safely withstand the thrust developed by D engines. The Estes D engine fits snugly inside a BT-____ body tube.

11. When launching live animals (as insects or fish) as passengers in payload-carrying model rockets, every care should be taken to provide for the passenger's comfort and safety, and the launch should not be made unless there is valid scientific reason for it.

    True or false?_____.

12. In a Drag Race, one point is awarded to the rocket reaching the ground first.

    True or false?_____.

13. The "moment" used in calculating the center of gravity in the design of stable rockets (in TR-9) is determined by multiplying the_____ of each part times the distance between the center of gravity of that part and the reference line.

14. The first letter or number and letter combination for model rocket engine classification indicates the _____ of the engine.

15. Which will cause a given model rocket to accelerate faster, a B14-5 engine or a B4-6 engine?_____.

16. The rate at which an object changes speed is called its_____.

17. The distance between the tracker and the launch pad in single station tracking is called the_____.

18. A solid propellant is composed of a mixture of_____

19. and_____ in solid form.

20. Velocity is_____.

21. The momentum of a moving object is equal to its____

22. times its_____.

23. Yaw is rotation about the_____ axis.

24. The speed of a rocket at the time all of its propellant has been used is called the_____.

25. The loss of effective thrust from a model rocket engine which occurs when the engine is recessed forward in the body tube more than one diameter of the body is called the_____.

ANSWERS

1. C
2. D
3. E
4. three
5. ½A6-0, A8-0, B14-0, C6-0
   D12-0
6. F
7. 180 feet
8. B
9. Four
10. BT-50
11. T
12. F
13. Weight
14. Total impulse or power
15. B14-5
16. Acceleration
17. Base line
18. Fuel
19. Oxidizer
20. The speed or rate of motion
21. Mass
22. Velocity
23. Vertical
24. Burnout velocity
25. Krushnik effect

ANSWERS

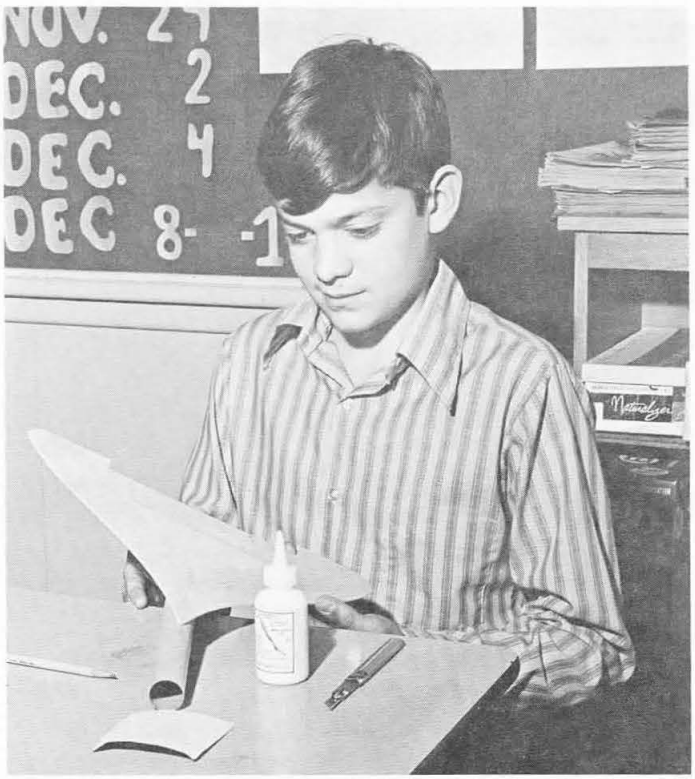
NOTES

SECTION III

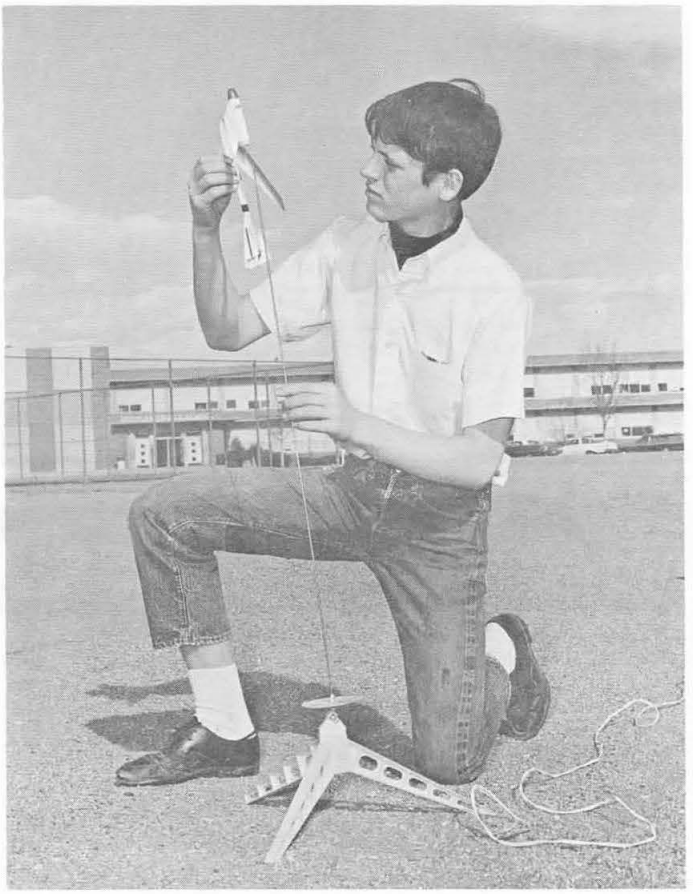
BOOST-GLIDERS

Not all model rockets look like rockets, some appear to be airplanes. The design and construction of model rocket gliders, or boost-gliders, provides one of the most challenging areas of model rocket activity. Continue your efforts toward becoming an Expert rocketeer and learn the skills of boost-glider modeling by following Section III of the Model Rocketry Study Guide.

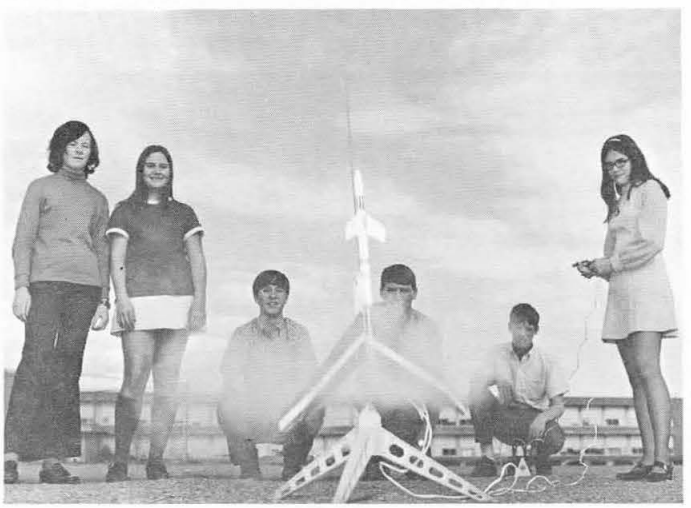
T-5 Learn the basic concepts of model rocket boost-gliders by reading Technical Report TR-4, "Rear Engine Boost-Gliders". Construct and fly a rear engine boost-glider such as the Astron SkyDart to gain the knowledge and skills necessary for proper trimming.



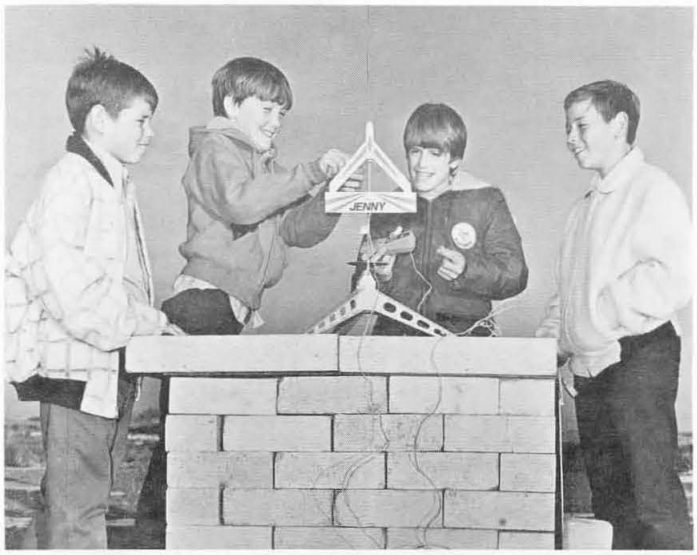
T-4 Study Technical Report TR-7, "Front Engine Boost-Gliders", to learn more about advanced principles of boost-glider design. Construct and fly a front engine boost-glider such as the Astron Falcon and compare its duration times with those of the Astron SkyDart.



T-3 Continue your boost-glider activities with the construction of the Astron Nighthawk to learn about pop-pod boost-gliders. This type of glider is propelled by a power pod which separates at apogee and returns on its own parachute. The airframe returns by gliding.



T-2 Now that you have constructed and flown rear engine, front engine, and pop-pod boost-gliders, design your own boost-glider using the principles and techniques gained from past experience. The testing of various methods, designs, and materials will greatly expand your knowledge of the physics of flight. The developments made in the field of boost-gliders contribute to the entire art of model rocketry.



T-1 This project is optional as it requires a high degree of skill in craftsmanship and rather expensive construction costs. By carrying out this project you will participate in the most exciting and advanced area of model rocket boost-glider activity. Assemble and fly model rocketry's first multi-channel radio-controlled glider, the "D" engine powered Estes Sky Dancer with a friend or as a club project.

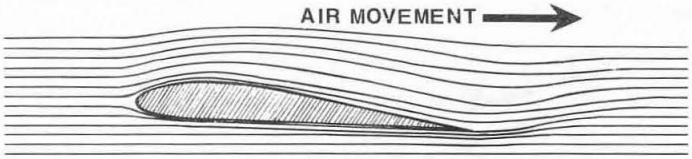
NOTES

GLOSSARY

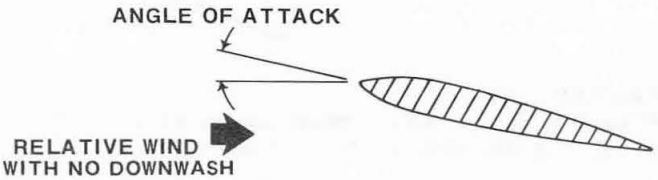
GLIDER TERMS

Airframe:
The structure of an aeronautical device; the form that gives the vehicle its shape and strength; usually includes fuselage, wings, and flight control surfaces, but does not include engines.

Airflow:
The movement of air across a surface.

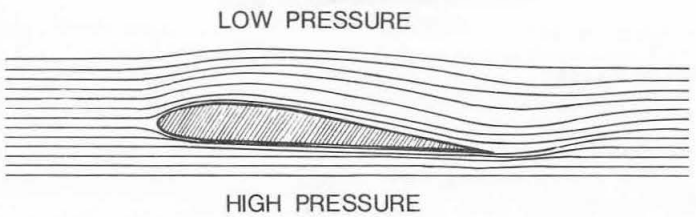


Angle of Attack:
The angle at which a wing strikes the air stream.



Aspect Ratio:
The relationship of the wing span length to the wing chord expressed numerically by the number of times the span can be divided by the chord (straight line drawn connecting leading and trailing edges of an airfoil).

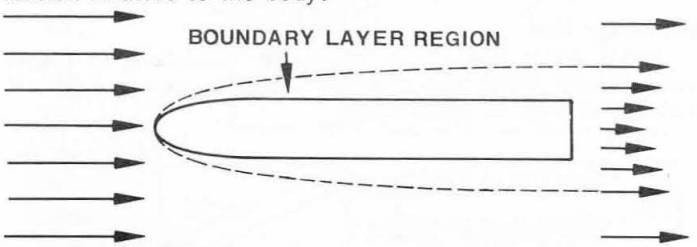
Bernoulli's Law:
Established by Swiss physicist Daniel Bernoulli and states that when the velocity of a fluid (as air) is increased (as by flowing around an airfoiled surface) the lateral (sideways) pressure exerted by the fluid is decreased; a wing produces lift by the pressure difference between the air flowing over its upper surface and the air flowing beneath its lower surface.



Boost Glider:
It is a combination rocket and glider; the rocket engine provides thrust to launch the glider which returns slowly to the ground by an aerodynamic glide; a parasite which rides on another vehicle (a rocket) for the launch phase and, near apogee, jettisons from its powered unit and glides back to earth; the glider has wings airfoiled to provide aerodynamic lift for the return glide.

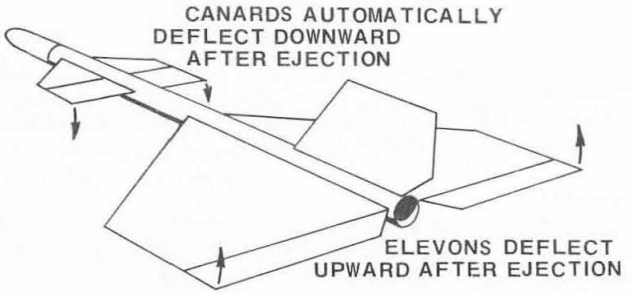
Boost Phase:
Period of powered flight for a glider when the rocket engine is providing thrust.

Boundary Layer:
The region next to the surface of a solid body moving through a fluid where there is an appreciable loss of fluid motion relative to the body.

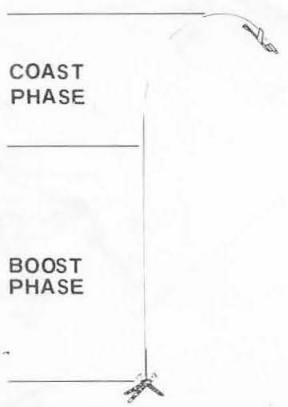


Camber:
In aeronautics, the rise of the curve of an airfoil section; usually expressed as the ratio of the departure of the curve from a straight line joining the extremities of the curve to the length of this straight line; camber is positive when the departure is upward, and negative when it is downward.

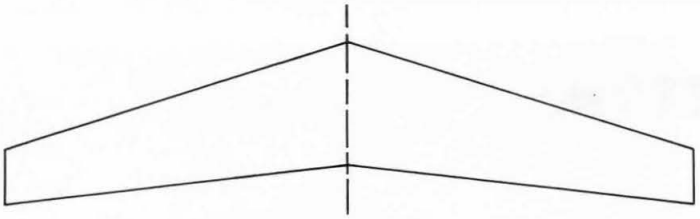
Canard:
An airframe configuration with the wings at the rear end and the pitch controlling surface at or near the nose.



Coast Phase:
The period following the boost phase when the model climbs unpowered prior to transition to gliding flight.

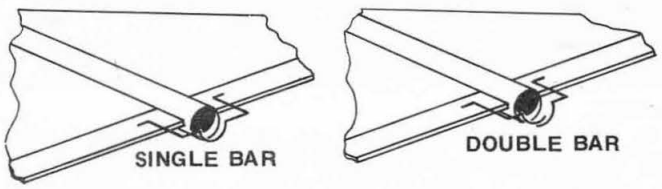


Constant Taper:
A wing in which the chord or the thickness progressively decreases from root to tip.



Convex-concave Airfoil:
A combination convex-concave curve on the underside of an airfoil.

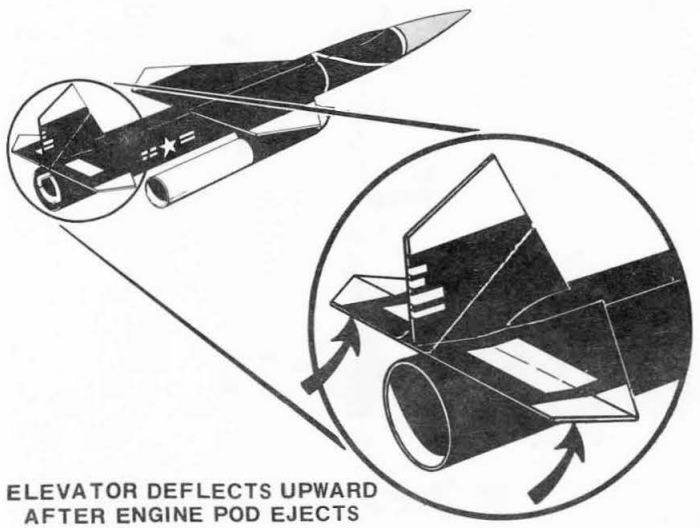
Depressor Bar:
Small metal bar which holds the elevators in place during boost phase and changes position upon ignition of ejection charge for glide phase.



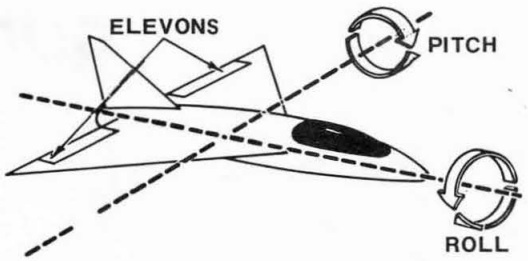
Dihedral:
The upward or downward inclination of a wing or other supporting surface with respect to the horizontal.

Downwash:
The vertical downward motion of the airflow induced by, and behind, an airfoil or a wing.

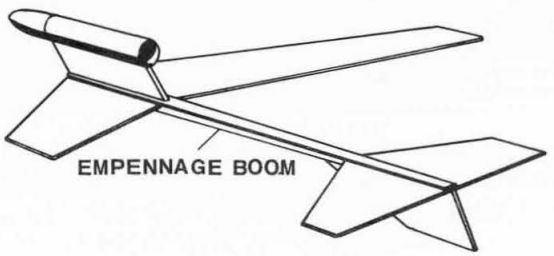
Elevators:
The control surface on a boost glider; this surface is designed to change, upon activation, the attitude of the craft from a stable rocket to a gliding object.



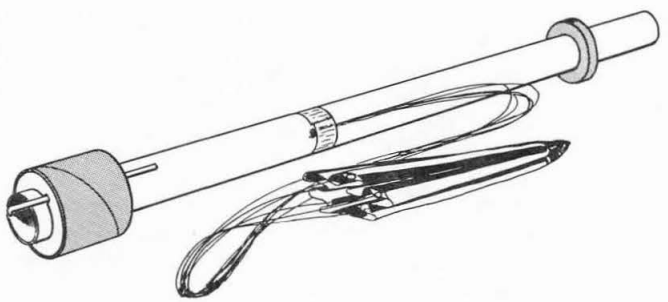
Elevon:
An aerodynamic control surface used to control both pitch and roll simultaneously or separately.



Empennage Boom:
Glider frame projecting back from the wings and to which the stabilizer and rudder are attached.



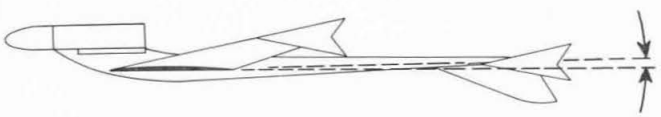
Engine Pod:
Assembly housing model rocket engine which detaches from rest of glider when ejection charge operates.



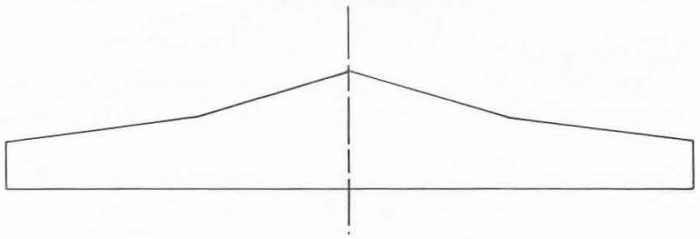
Flat Bottom Airfoil:
Airfoil with flat underside.

Glide Phase:
The non-powered descent of a glider.

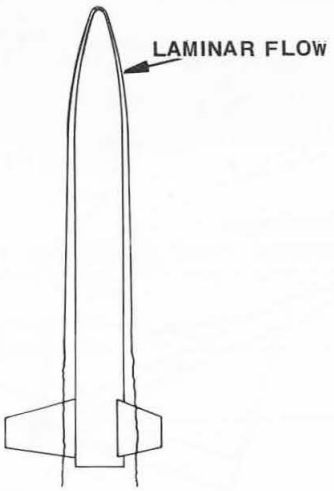
Incidence:
The angle between the chord line of the airfoil and the longitudinal axis of the glider.



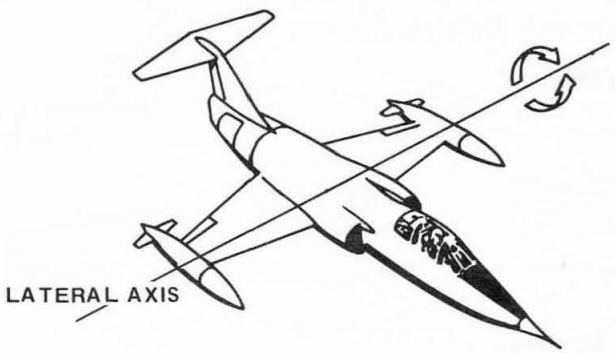
Irregular Taper:
A wing in which the chord or thickness does not progressively decrease from root to tip.



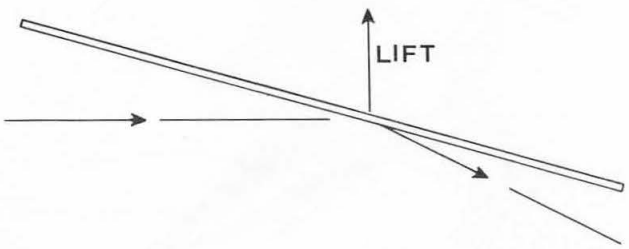
Laminar Flow:
Non-turbulent airflow near the surface of a body; airflow parallel to the surface, usually found at the front of a smooth body.



Lateral Axis:
The axis from wing tip to wing tip of an aircraft; the aircraft can pitch up or down about this axis.



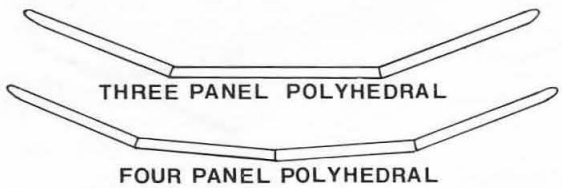
Lift:
The component of the total aerodynamic force perpendicular to the relative wind and exerted normally (in an upward direction opposing the force of gravity) to the wings.



Longitudinal Axis:
The axis from the nose to tail of an aircraft; movement about this axis is called roll.

Oscillation:
A periodic motion such as the rolling, pitching, or yawing of an aircraft or a combination of these.

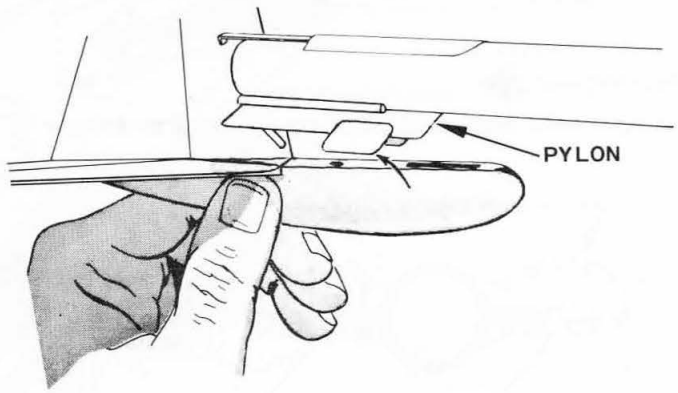
Polyhedral:
A modification of dihedral, wherein the different panels of a wing are tilted upward at varying angles.



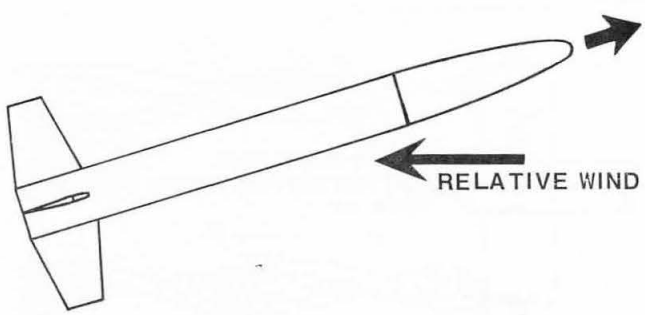
Pop-pod:
Engine pod which is jettisoned from glider as the glide phase is initiated.

Pressure Distribution:
The variation of air pressure over a surface, such as the pressures around an airfoil.

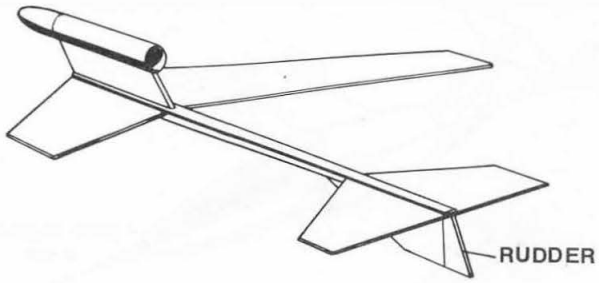
Pylon:
A fin-like mount for the pop-pod.



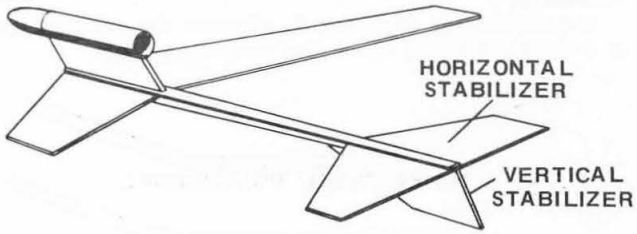
Relative Wind:
The direction of the air with reference to a body in it.



Rudder:
A moveable aerodynamic control surface used to cause yaw rotations.

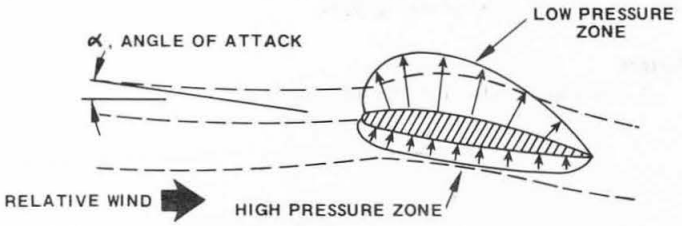


Stabilizer:
A fixed stabilizing surface; generally the tail surfaces on conventional models and the forward surfaces on canard models.

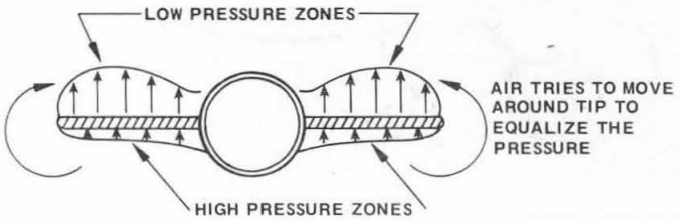


Taper Ratio:
The ratio of the tip chord to the root chord of a wing; also the ratio of the thickness of the root section to the thickness of the tip section of a wing.

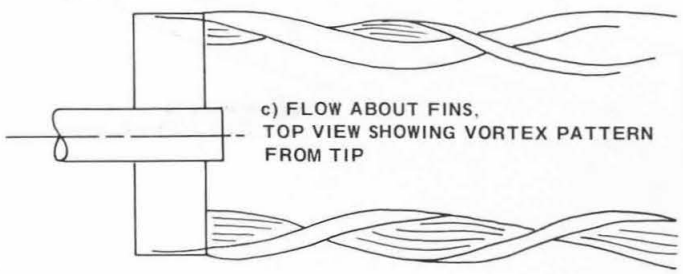
Tip Vortex:
Twisting air disturbance at the tip resulting from the wing acting on the air to generate lift.



a) FLOW OVER CROSS-SECTION OF FIN AT ANGLE OF ATTACK

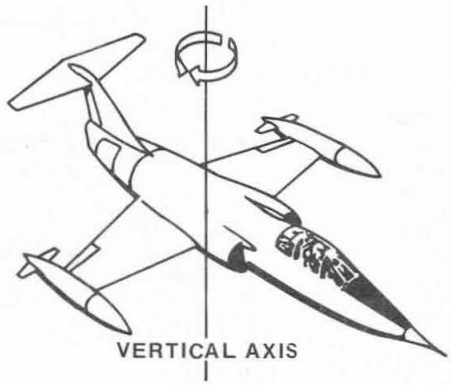


b) FLOW ABOUT FINS, FRONT VIEW OF ROCKET AT ANGLE OF ATTACK

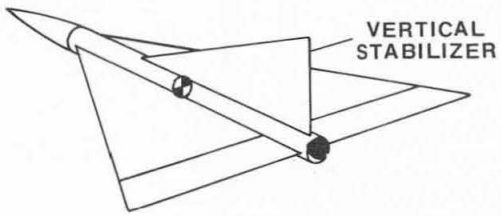


Undercambered Airfoil:
An airfoil possessing a concave curve on its underside.

Vertical Axis:
The axis extending in a vertical direction from the glider's center of gravity; movement about this axis is called yaw.



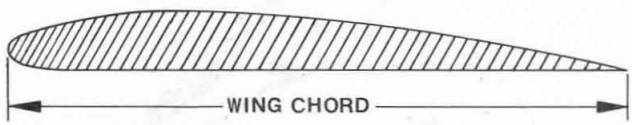
Vertical Stabilizer:
The vertical fixed stabilizing surface of a glider.



Warp:
A twist in the chord line of a surface across its span.

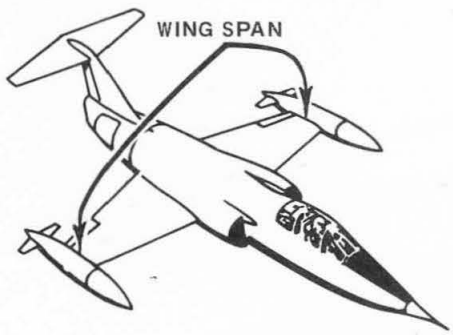
Wing:
The main lifting surface of an aircraft.

Wing Chord:
The length of a straight line through the centers of curvature of the leading and trailing edges of an airfoil.



Wing Loading:
The gross weight of the glider divided by the gross wing area.

Wing Span:
The overall distance between the wing-tips of an aircraft.



NOTES

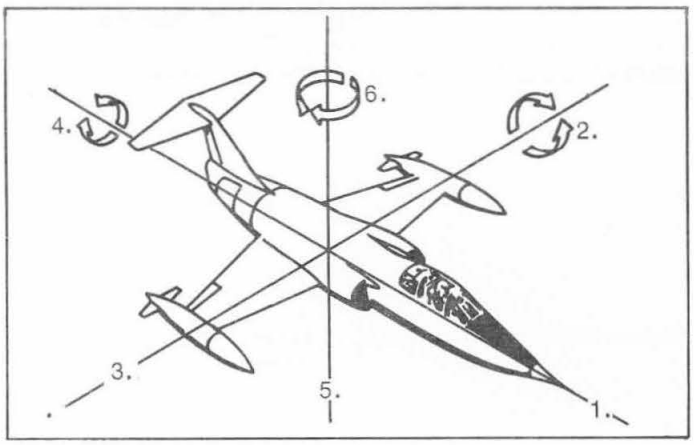
SECTION TEST

SECTION III

Review what you have learned in Section One, Section Two, and Section Three before starting this test. Do not refer back to any of the materials you have used while taking this test. Good luck!

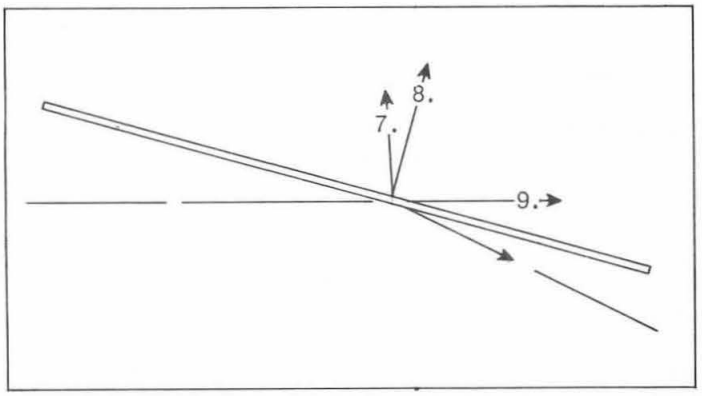
Label the parts indicated in this drawing:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____



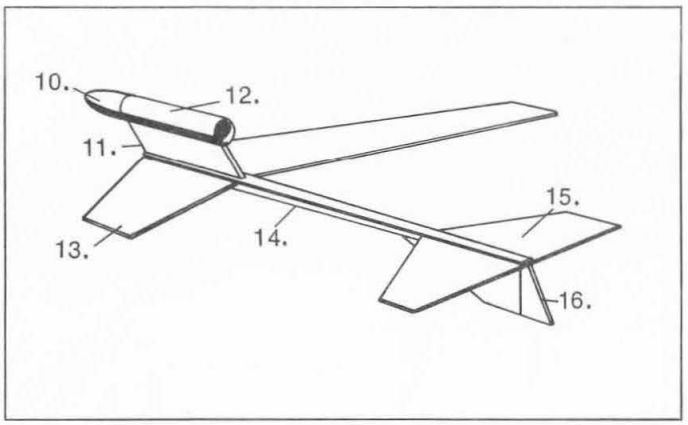
Label the numbered arrows for the force they represent.

7. _____
8. _____
9. _____



Label the parts indicated on the front-engine boost glider.

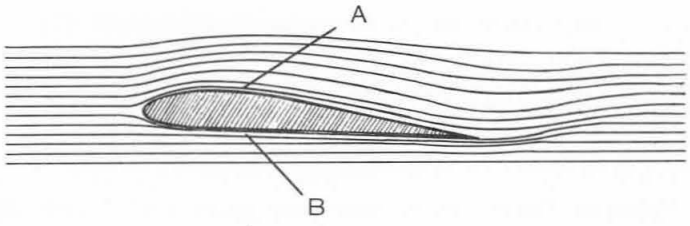
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____



Answer the following questions based on the drawing below.

17. The highest air velocity occurs at _____.

18. The highest air pressure against the wing occurs at _____.

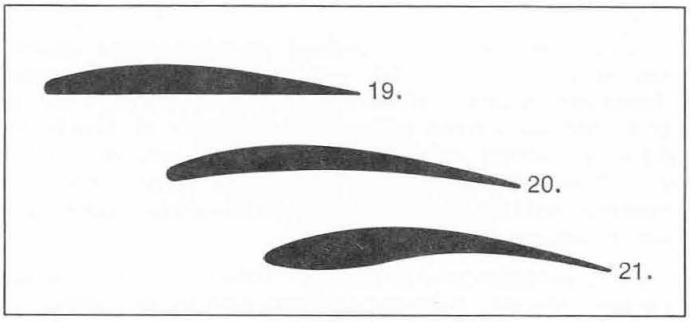


Label the three types of airfoils shown.

19. _____

20. _____

21. _____



22. The angle between the chord line of the airfoil and the longitudinal axis of the glider is called the angle of _____.

23. The gross weight of the glider divided by the gross wing area is called the _____.

24. The region next to the surface of a solid body moving through a fluid where there is an appreciable loss of fluid motion relative to the body is called the _____ _____.

25. The non-turbulent airflow near the surface of a body is called _____ flow.

ANSWERS

ANSWERS

1. Longitudinal axis
2. Pitch
3. Lateral axis
4. Roll
5. Vertical axis
6. Yaw
7. Lift
8. Reactive force or net force
9. Drag
10. Nose cone
11. Pylon
12. Engine pod
13. Wing
14. Empennage boom
15. Stabilizer
16. Rudder
17. A
18. B
19. Flat bottom
20. Undercambered
21. Convex-concave
22. Incidence
23. Wing loading
24. Boundary layer
25. Laminar

NOTES

When you have followed the Model Rocketry Study Guide step by step, completed all suggested projects, completed each section test, and carried on all launch activities in strict accordance with the "Model Rocketry Safety Code", you are prepared to take the Expert Rocketeer Final Exam at the end of this booklet. When you have completed the test, please send us your answer sheet with 50¢ for checking and handling so we can inform you of your score.

Upon receiving your answer sheet we will check it and return it to you. We will include an official Expert Rocketeer Award Certificate if you qualify. This personalized certificate represents a series of challenging projects carried out and successfully accomplished by you. The experience and knowledge gained from your endeavor will be of future value in advanced model rocket and aerospace studies.

As a personal way of saying "Thanks" to you for your sincere interest in model rocketry and to encourage you to pursue your studies in this exciting field, I would like you to have, with my compliments, one of our Technical Reports. Just fill out the coupon printed at the end of the Final Examination, telling us which TR you'd like to have, and mail it. That's all there is to it.

Good luck with the Final Exam!!!

Sincerely,

Vern

Vern Estes
President

EXPERT ROCKETEER AWARD

THIS CERTIFICATE IS AWARDED TO_____FOR OUTSTANDING ACCOMPLISHMENTS IN THE FIELD OF MODEL ROCKETRY. BY SUCCESSFULLY COMPLETING THE PROJECTS OFFERED IN THE MODEL ROCKETRY STUDY GUIDE YOU HAVE EARNED THE MOST HONORED STATUS OF EXPERT ROCKETEER.

THE EXPERIENCE, KNOWLEDGE, AND EXPERTISE GAINED IN ATTAINING THIS STATUS, ENABLES YOU TO CARRY OUT RESEARCH AND DEVELOPMENT IN ALL AREAS OF MODEL ROCKET ACTIVITY WHERE YOUR CONTRIBUTIONS WILL BENEFIT THE ENTIRE HOBBY.

ESTES
A SUBSIDIARY OF DAMON

DATE _____

ATTEST WITNESS _____

VERN ESTES, PRESIDENT
ESTES INDUSTRIES

FINAL EXAM

This is <u>not</u> an "open book" test, so before you start review what you have learned about model rocketry as you progressed toward becoming an "Expert" model rocketeer. Good luck!

1. My model rocket will weigh no more than_____ ounces (453 grams) at lift off.

2. The total amount of propellant in my model rocket will not be more than_____ounces (113 grams).

3. I will always test my model rockets for stability before launching them, except when launching models of proven stability. True or false?_____

4. I will use only pre-loaded, factory-made model rocket engines in my solid propellant model rockets. True or false? _____

5. My model rockets will be launched by an_____ operated launch system.

6. To be aerodynamically stable:_____

   (A) The center of gravity should be ahead of the center of pressure.

   (B) The center of gravity and the center of pressure should be in the same place.

   (C) The center of pressure should be ahead of the center of gravity.

7. The total impulse of a C6-5 engine is_____times that of an A8-3 engine.

Name three recovery systems.

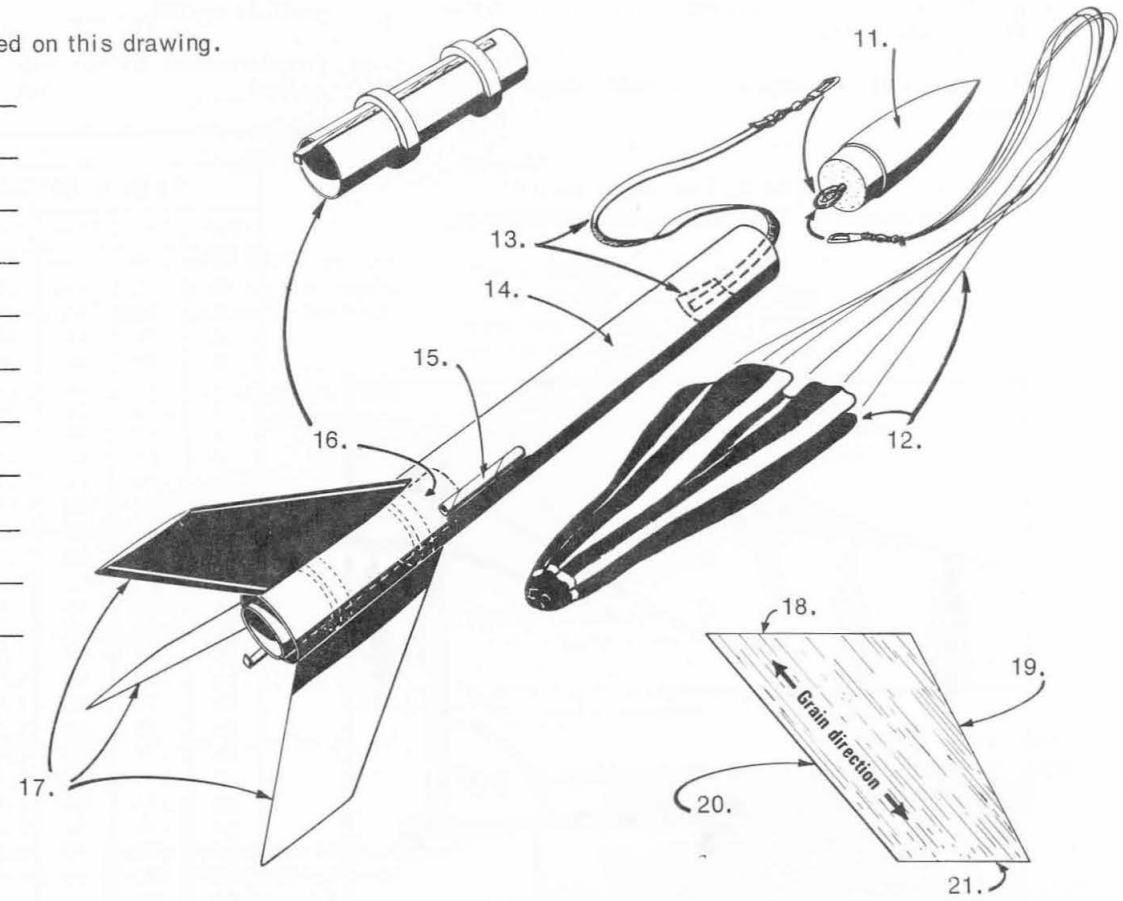
8. _____

9. _____

10. _____

Label the parts indicated on this drawing.

11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____



Label the parts shown in this drawing of a model rocket engine.

22. _____

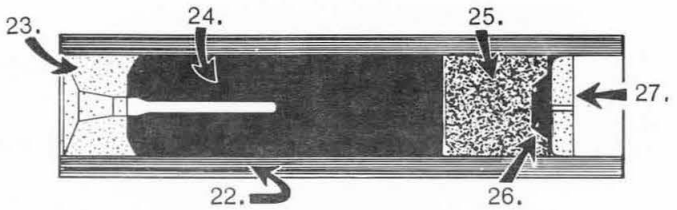
23. _____

24. _____

25. _____

26. _____

27. _____



28. A D12-5 engine has a total impulse of _____ Newton-seconds.

29. The D12-5 engine has a delay element which activates the ejection charge _____ seconds after the propellant is consumed.

30. A C6-0 engine would be used to: _____

(A) Launch a large, heavy, single-stage model rocket

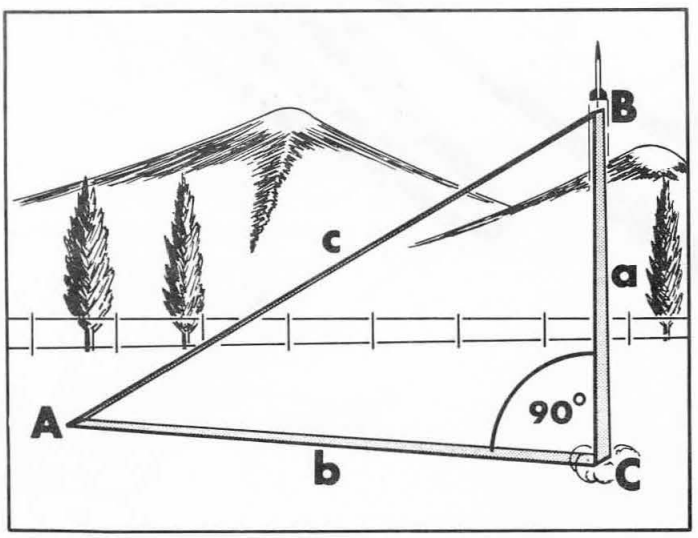
(B) As the engine in a booster stage of a multi-stage model rocket

(C) As the sustainer engine in a multi-stage model rocket

31. Calculate the height of the model rocket at point B. _____ feet.

Given: baseline b = 500 ft.

$\angle A = 42°$



32. My model rockets will always be pointed within _____ degrees of vertical.

33. A cluster of 3 A8-3 engines produces _____ times the total impulse of one A8-3 engine.

34. The total impulse of a model rocket engine is indicated by the: _____

(A) First letter (or fraction and letter) of the engine classification

(B) The first number (not a fraction) of the engine classification

(C) The second number (after the dash) of the engine classification

35. Which will accelerate a given model rocket faster, a B14-5 engine or a B4-6 engine? _____

36. Solid propellant is composed of a mixture of _____

37. and _____.

38. Burnout occurs when the rocket engine _____ _____.

39. The edge at which the fin or wing is attached to the tube is called the _____.

40. The length of time during which a model rocket is airborne is called the _____.

41. Rotational movement around the lateral axis of a craft is called _____.

42. The science of sending data from a rocket back to earth is called _____.

43. Non-turbulent airflow near the surface of a body is called _____ flow.

TABLE OF TANGENTS

Angle	Tan.	Angle	Tan.	Angle	Tan.
1°	.02	28°	.53	54°	1.38
2	.03	29	.55	55	1.43
3	.05	30	.58	56	1.48
4	.07	31	.60	57	1.54
5	.09	32	.62	58	1.60
6	.11	33	.65	59	1.66
7	.12	34	.67	60	1.73
8	.14	35	.70	61	1.80
9	.16	36	.73	62	1.88
10	.18	37	.75	63	1.96
11	.19	38	.78	64	2.05
12	.21	39	.81	65	2.14
13	.23	40	.84	66	2.25
14	.25	41	.87	67	2.36
15	.27	42	.90	68	2.48
16	.29	43	.93	69	2.61
17	.31	44	.97	70	2.75
18	.32	45	1.00	71	2.90
19	.34	46	1.04	72	3.08
20	.36	47	1.07	73	3.27
21	.38	48	1.11	74	3.49
22	.40	49	1.15	75	3.73
23	.42	50	1.19	76	4.01
24	.45	51	1.23	77	4.33
25	.47	52	1.28	78	4.70
26	.49	53	1.33	79	5.14
27	.51			80	5.67

44. The axis from wing tip to wing tip of an aircraft is called the_____ axis.

45. The velocity of air with reference to a body in it is called the_____.

Label the parts in this drawing:

46._____

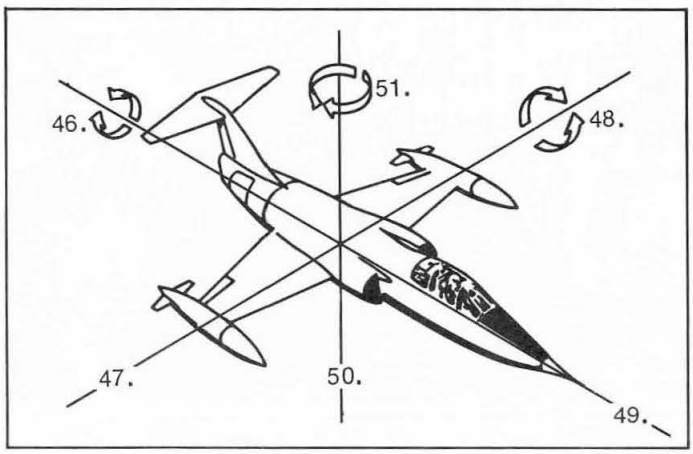
47._____

48._____

49._____

50._____

51._____



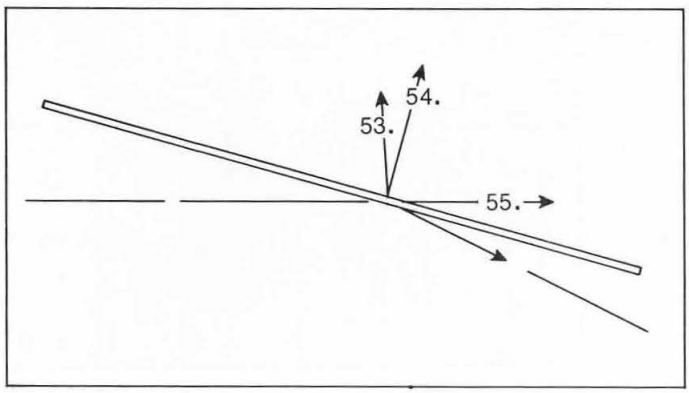
52. The overall distance between the wing tips of an aircraft is called the_____.

Label the arrows to indicate the force which each represents.

53._____

54._____

55._____



Now that you have completed the examination, we know you are interested in finding out your test score.

Enclose 50¢ for checking and handling and mail your examination paper to us today. We will grade your paper and return it to you with your expert model rocketeer certificate (providing you pass).

At this time we would like to help you continue with your hobby, so we are going to send you, free of charge, any one of the technical reports listed below. All you have to do is fill out the coupon designating which report you would like us to send you, and we will send it with your test score and certificate.

PLEASE SEND ME MY FREE TECHNICAL REPORT. ENCLOSED IS MY ANSWER SHEET AND 50¢.

DATE _____

NAME _____

STREET ADDRESS _____ **CITY** _____ **STATE** _____ **ZIP** _____

CHECK TECHNICAL MANUAL DESIRED.

TR-1 Rocket Stability ☐
TR-2 Multi-Staging ☐
TR-3 Altitude Tracking ☐
TR-4 Rear Engine Boost-Gliders ☐
TR-5 Building A Wind Tunnel ☐
TR-6 Cluster Techniques ☐
TR-7 Front Engine Boost-Gliders ☐
TR-8 Model Rocketry Study Guide ☐
TR-9 Designing Stable Rockets ☐
TR-10 Altitude Prediction Charts ☐
TR-11 Aerodynamic Drag of Model Rockets ☐

MODEL ROCKETRY STUDY GUIDE – "PROJECT/FLIGHT RECORD"

SECTION I	PROJECT DESCRIPTION	DATES: BEGUN / COMPLETED	REF. MAT. READ OR TESTS TAKEN	ROCKET: NAME/TYPE	STABLE FLIGHT	PERFORMANCE: DURATION/ALT.	SUCCESSFUL RECOVERY	ATTEST: SELF OR WITNESS
T-10								
T-9								
T-8								
T-7								
T-6								
T-5								
T-4								
T-3								
T-2								
T-1								
*SECTION TEST								
SECTION II								
T-10								
T-9								
T-8								
T-7								
T-6								
T-5								
T-4								
T-3								
T-2								
T-1								
*SECTION TEST								
SECTION III								
T-5								
T-4								
T-3								
T-2								
T-1								
*SECTION TEST								
**EXPERT ROCKETEER FINAL EXAM								

NAME

ADDRESS

CITY STATE ZIP CODE

ROCKETEER'S CERTIFICATION OF COMPLETION

I hereby certify that I have successfully completed, in strict accordance with the Model Rocketry Safety Code, the projects offered in the Model Rocketry Study Guide.

DATE _____ WITNESS _____ ROCKETEER _____

Get more out of model rocketry... Join the estes aerospace CLUB

The most exciting hobby on Earth is even more fun when you are a member of the most exciting rocket club on Earth—The Estes Aerospace Club.

As soon as you join, you receive your own special EAC membership kit that includes the following exciting items:

VIPER ROCKET—Special kit designed exclusively for members of the Estes Aerospace Club. Features sleek styling, parachute recovery, and Mini-Brute power for maximum high performance. The Viper is the first special kit which will be available *only* to EAC members.

MEMBERSHIP CARD—Impressive I.D. card identifying you as an official member of the Estes Aerospace Club. Wallet size card features identification information, rocket safety code, chapter affiliation information, and your own rocketeer achievement record.

MEMBERSHIP CERTIFICATE—Handsome membership certificate signifying your EAC affiliation. Suitable for framing.

CLUB EMBLEM—Official iron-on patch with EAC insignia. Perfect for tee shirt or jacket, and lets the world know you are a member of the EAC. And as you progress to higher skill levels, you'll receive additional iron-on "thrust bars" signifying your achievements.

DECAL SHEET—Special EAC rocket decals to identify your models as part of the EAC fleet.

RANGE BOX STICKERS—Bright, multipurpose stick-ons for your range equipment.

EAC STATIONERY—Distinctive EAC rocketeer stationery for your most important notes and letters. Makes corresponding fun.

MODEL ROCKETRY TECHNICAL MANUAL—16-page technical manual covering a variety of model rocketry topics. Includes information on construction techniques, finishing, stability, tracking, recovery systems, multi- staging, and boost gliders, plus many other subjects.

MODEL ROCKET NEWS—Subscription to model rocketry's most exciting publication. Features free plan designs, technical articles, cartoons, contests, construction hints, rocketeer contributions, special projects, and much, much more.

EAC PRODUCTS SHEET—Special club flier featuring exciting items like club jackets, patches, and tee shirts, plus outstanding offers for EAC kits, parts and accessories, rocket plans and technical publications which will be available *only* to EAC members. Remember, your money flies further in the EAC.

EAC ACTION BOX—Membership kit box doubles as sturdy cardboard carrying case for your model rocketry materials.

Membership in the Estes Aerospace Club opens up a whole new world of exciting model rocket activities. Your EAC membership kit is just the beginning.

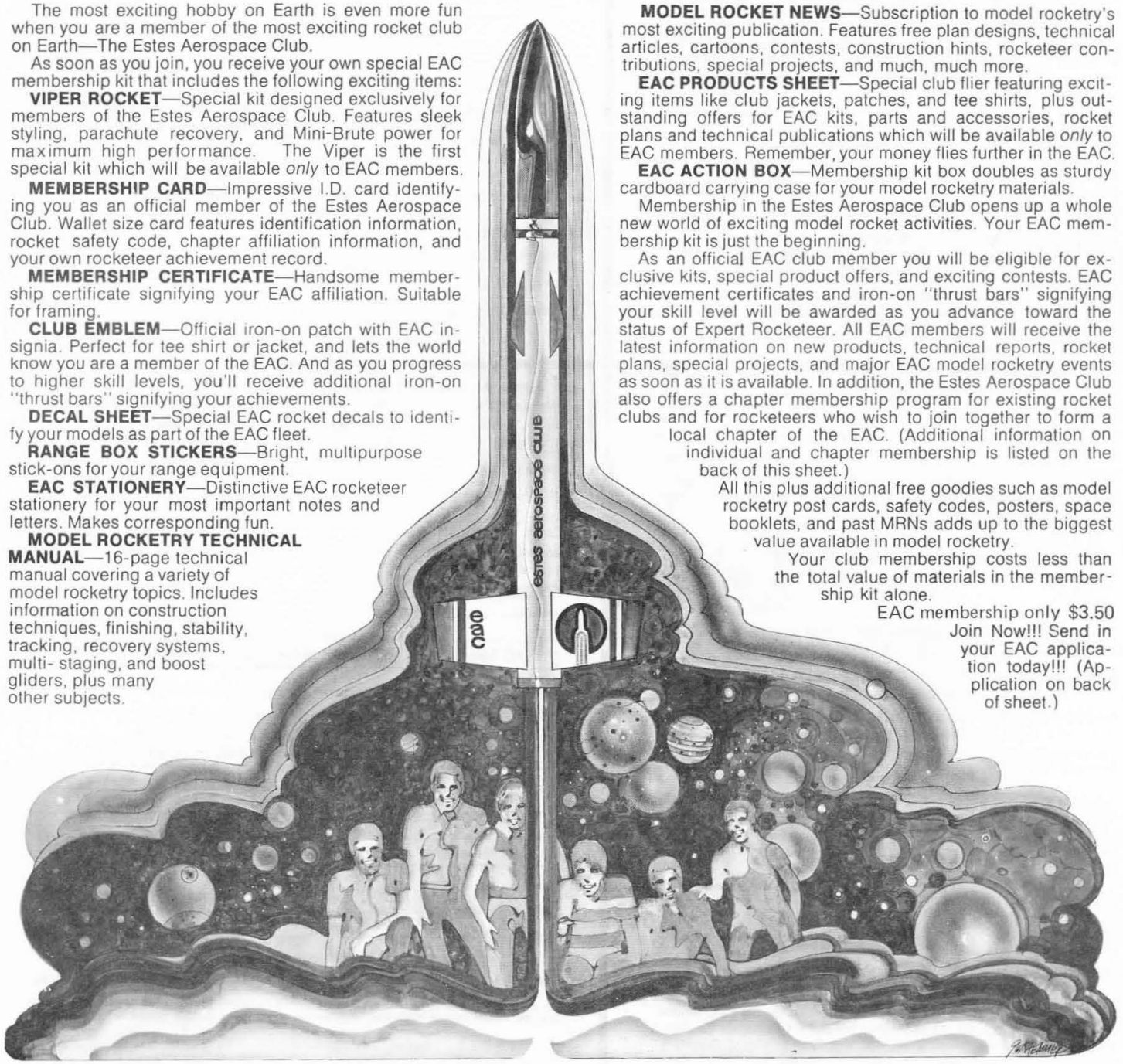
As an official EAC club member you will be eligible for exclusive kits, special product offers, and exciting contests. EAC achievement certificates and iron-on "thrust bars" signifying your skill level will be awarded as you advance toward the status of Expert Rocketeer. All EAC members will receive the latest information on new products, technical reports, rocket plans, special projects, and major EAC model rocketry events as soon as it is available. In addition, the Estes Aerospace Club also offers a chapter membership program for existing rocket clubs and for rocketeers who wish to join together to form a local chapter of the EAC. (Additional information on individual and chapter membership is listed on the back of this sheet.)

All this plus additional free goodies such as model rocketry post cards, safety codes, posters, space booklets, and past MRNs adds up to the biggest value available in model rocketry.

Your club membership costs less than the total value of materials in the membership kit alone.

EAC membership only $3.50

Join Now!!! Send in your EAC application today!!! (Application on back of sheet.)



eac

MEMBERSHIP APPLICATIONS

INDIVIDUAL MEMBERSHIP

The other side of this page is loaded with exciting things you get when you join the Estes Aerospace Club. But that's just a beginning—there's a lot more. You'll also get a variety of exclusive club services in addition to the exciting items in your EAC Membership Kit.

- As an EAC member you will receive a special iron-on club insignia. This club emblem is styled to accommodate four additional iron-on thrust bars, each a different exciting color, signifying your EAC skill level and your advancement toward the status of Expert Rocketeer. (Details on skill level requirements and advancement will be included with your Membership Kit.)
- You'll be eligible to participate in special projects and contests open only to EAC members—many of them involving valuable prizes.
- You'll be the first to receive the latest information concerning new rocketry products.
- You'll have the opportunity to be selected as a member of the EAC Advisory Board, which will suggest new product ideas to Estes Industries. EAC Advisory Board members may be asked to test fly new rocket designs and comment directly to Estes engineers.
- Your EAC membership will remain in effect for as long as you remain an active Estes rocketeer.
- Further details on all these exciting programs will be included with your EAC Membership Kit.

To become an official member of the Estes Aerospace Club, simply fill out the application. We'll send your entire kit the same day we get your application. So join now—become an EAC Rocketeer today!

Estes Aerospace Club INDIVIDUAL MEMBERSHIP APPLICATION

Send to: Estes Industries
EAC Headquarters, Dept. 14
Penrose, Colorado 81240

☐ I would like to become an official EAC member. Please rush my EAC membership kit to me immediately. Enclosed is $3.50

☐ Cash ☐ Check ☐ Money Order

Name_____

Address_____

City_____ State_____ Zip Code_____

Dept. 14

As an official member of the Estes Aerospace Club, I promise to follow all EAC rules and to carry out all my model rocketry activities in accordance with the Model Rocketry Safety Code.

Signed_____
Rocketeer Signature

☐ Also please send an Estes Aerospace Club application to:

Name_____

Address_____

City_____ State_____ Zip Code_____

Send to: Estes Industries
EAC Headquarters, Dept. 14
Penrose, Colorado 81240

CHAPTER MEMBERSHIP

Special EAC Chapter Membership is available to existing rocket clubs or to EAC members wishing to join together to form a local chapter of the Estes Aerospace Club. Chapter membership opens up a universe of exciting model rocket activities for EAC rocketeers. New chapters receive a payload of fantastic club supplies, including:

CHAPTER MEMBERSHIP KIT

Chapter Wall Certificate	Handsome chapter certificate signifying your club's EAC affiliation. Suitable for framing and perfect for clubhouse or workshop.
Technical Report Collection	Outstanding collection of all Estes' technical reports and technical notes. A must for all club libraries.
EAC Wall Poster	Colorful wall poster identifies your club as an official EAC chapter.
Deluxe Safety Code	Large Model Rocketry Safety Code suitable for framing.
"Guide for Aerospace Clubs"	Complete club guide for EAC chapters. Explains club organization and how to plan and carry out all types of exciting model rocket activities.
"Model Rocket Contest Guide"	Complete contest guide for organizing your EAC rocket meets. Details on ten different types of competitive events.
EAC Contest Kit	Includes 12 award certificates plus flight data sheets for EAC competition.
"Launch Systems Booklet"	Explains the various types of safe launch systems and tells how to make your own multi-pad club launch system.
EAC Range Box Stickers	Additional, multi-purpose EAC stick-ons for your club and range equipment.
EAC Iron-on Emblems	Additional iron-on club insignias for your teeshirts or jackets.

Your chapter membershio kit includes all this plus special EAC chapter services for only . .$4.00. To become an official EAC Chapter you must have at least four rocketeers (Club President, Vice-President, Secretary-Treasurer, and at least one additional member) who are EAC members. Simply fill out the chapter application and become an EAC Chapter today!

Estes Aerospace Club CHAPTER MEMBERSHIP APPLICATOIN

We would like to become an official chapter of the Estes Aerospace Club. Enclosed is $4.00 for our EAC Chapter Membership Kit.

☐ Cash ☐ Check ☐ Money Order

Chapter/Club Name_____

Mailing Address_____

City_____ State_____ Zip Code_____

Dept. 14

MEMBERS (at least 4 EAC Rocketeers are required to become an official chapter):

President's Name_____

Address_____

City_____ State_____ Zip Code_____

☐ EAC Member ☐ Joining now ($3.50 enclosed)

Vice President's Name_____

Address_____

City_____ State_____ Zip Code_____

☐ EAC Member ☐ Joining now ($3.50 enclosed)

Sec.-Treas.'s Name_____

Address_____

City_____ State_____ Zip Code_____

☐ EAC Member ☐ Joining now ($3.50 enclosed)

Member's Name_____

Address_____

City_____ State_____ Zip Code_____

☐ EAC Member ☐ Joining now ($3.50 enclosed)

IMPORTANT: If "joining now" is checked, membership application(s) and membership fee(s) must be enclosed.

As an official Chapter of the EAC, we promise to follow all the EAC rules and to carry out all model rocket activities in accordance with the Model Rocketry Safety Code.

Signed_____
Chapter President

SEND TO: Estes Industries
EAC Headquarters, Dept. 14
Penrose, Colorado 81240

Technical Reports

ROCKET STABILITY:
All about rocket stability. Easy-to-read, tells how rockets are designed to fly properly. Contains before-launch tests to assure rocket stability. Technical Report TR-1.

MULTI-STAGING:
Tells all about the latest in multi-staging techniques. Complete, easy-to-understand, and well-illustrated. A necessity for designing, building, and flying multi-stage birds. Technical Report TR-2.

ALTITUDE TRACKING:
The classic work on simple altitude tracking of model rockets. Thoroughly covers basic tracking and altitude computation. Easy-to-understand and apply.Technical Report TR-3.

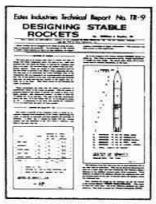
REAR ENGINE BOOST-GLIDERS:
Basic information for the design and operation of rear engine boost-gliders. Covers construction techniques and glide characteristics. Technical Report TR-4.

BUILDING A WIND TUNNEL:
Full plans and information for building a simple wind tunnel to study rocket stability. Covers motor and handpowered versions, finding center of pressure, checking multi-stage rockets, etc. Great for advanced rocketeers. An excellent class or club project. Technical Report TR-5.

CLUSTER TECHNIQUES:
The complete report on clustering engines in model rockets. Thoroughly illustrated, easy-to-understand. Essential for the student modeler who wishes to loft larger payloads. Technical Report TR-6.

FRONT ENGINE BOOST-GLIDERS:
Valuable information on designing, building, and flying front engine boost-gliders. Fully-illustrated. Recommended reading for anyone who wishes to build better gliders or get the best performance from the ones they have. Technical Report TR-7.

MODEL ROCKETRY STUDY GUIDE:
Presents a logical program for any student who wants the most from model rocketry. The planned sequence of activities will guide you on your path to becoming an expert model rocketeer. Technical Report TR-8.



DESIGNING STABLE ROCKETS:
Based on standard engineering practices, this report presents a method of designing rockets for proper stability on paper before any construction work is done. Technical Report TR-9.

ALTITUDE PREDICTION CHARTS:
Explains a relatively simple method by which aerodynamic drag and other atmospheric effects can be taken into account in predicting rocket peak altitudes. Includes suggestions for research projects. Technical Report TR-10.

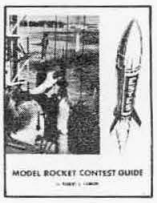
AERODYNAMIC DRAG OF MODEL ROCKETS:
Gives practical examples of ways to minimize aerodynamic drag and improve performance. All factors that influence drag are explained with the aid of graphs and illustrations. Technical Report TR-11.

Model Rocketry Publications

IS THAT PARACHUTE TOO BIG?
Discusses techniques to speed descent rates of parachutes yet prevent damage to rockets. Speeding descent reduces horizontal distance the rocket travels as winds cause it to drift during descent. Technical Note TN-3. (84702)

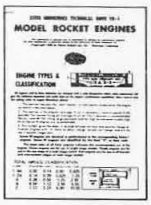
MODEL ROCKET LAUNCH SYSTEMS
Contains a wealth of information. Photographs and clearly drawn schematics make it easily understood. The electrical theory of launchers is explained, and a number of special study problems are included. 20 pages. (BK-12)

SPACE AGE TECHNOLOGY
A new, comprehensive textbook on man's achievements in rockets for space missions. Well-illustrated. Co-authored by an aerospace educator and a space scientist-engineer-educator. 52 pages. (BK-14)

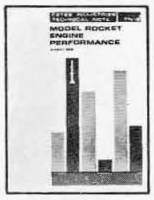


MODEL ROCKET CONTEST GUIDE
Use in planning model rocket contests for school classes and school-sponsored clubs. Contains details on types of competitive events and suggestions on all facets of contests from committee organization to championship awards. Includes sample score sheet. (BK-17)

THE FINE ART OF PAYLOAD LAUNCHING
Information on payload launching with data on possible payloads, available payload compartments, and suggestions on preparation and launch of payloads. Technical Note TN-4. (84703)



MODEL ROCKET ENGINES
Information on engine types, classifications, design, and performance. Time-thrust curves for Estes 1/4A through C engines are provided. Designed for reproduction on overhead projection transparencies. (TN-1)



MODEL ROCKET ENGINE PERFORMANCE
by Edwin D. Brown. This brochure explains the operation of model rocket engines. Well-illustrated, this 8 1/2 x 11" publication contains equations for calculating engine performance. (TN-2)

ESTES GUIDE FOR AEROSPACE CLUBS
Features complete details for club organization and activities. A must for active clubs. (BK-19)

MODEL ROCKET NEWS!

THE MODEL ROCKET NEWS is a regular publication of Estes Industries featuring up-to-date information on developments in model rocketry, action articles on the science of rocketry, rocketry plans, and news about rocketeers and rocketeering. Back issues, an important source of rocketry ideas, are available at nominal cost in the bound volume groupings listed below.

BEST OF VOLUMES 1 & 2:
Sixteen pages packed with the best ideas, plans, and information from Volumes 1 and 2. Shipping weight 4 oz. (Cat. No. 651-MRN-1)

VOLUMES 3 & 4:
Seven issues containing information on Science Fair projects, problem solvers from the Idea Box, altitude tracking information, safety tips, Technical Reports TR-2, TR-4, TR-6, and TR-7. Shipping weight 6 oz. (Cat. No. 701-MRN-34)

VOLUMES 5, 6, 7:
Six issues with comprehensive articles on many phases of model rocketry; electric launching systems; interesting R & D projects; model finishing; designing, turning, and finishing nose cones; altitude and drag calculation techniques; streamer information; how to display models; information on our nation's large space boosters; plans and parts lists for 8 new and unusual rockets, plus "Odd Balls", are included. Shipping weight 6 oz. (Cat. No. 701-MRN-567)

VOLUMES 8 & 9:
Five issues with many informative, appropriately illustrated, and easy-to-understand articles covering the science of rocketry. Shipping weight 6 oz. (Cat. No. 701-MRN-89)

VOLUME 10-1:
Twelve pages of news on an indoor launch, the past decade of model rocketry, calculating speeds, notes, and plans. Shipping weight 1 oz. (Cat. No. 711-MRN-V10-N1)

VOLUME 10-2:
Features stories about Cineroc, an article on acceleration, design tips, and plans. Shipping weight 1 oz. (Cat. No. 711-MRN-V10-N2)

EDUCATOR'S INFORMATION PACKET:
Designed specifically for teachers, these materials provide valuable information on how to incorporate model rocketry into the curriculum. Shipping weight 16 oz. (Cat. No. 711-EIP-2)

MODEL ROCKETRY LIBRARY PACKET:
The best and most complete collection of information on model rocketry available anywhere. Contains a complete set of technical reports, all previous editions of MODEL ROCKET NEWS -- everything you want and need to know about model rocketry! (Cat. No. 711-02818)

A SUBSIDIARY OF DAMON

ESTES INDUSTRIES
PENROSE, COLO. 81240